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Technology Transfer in the Navy Research and Development Community:

An Analysis of Private Industry and
Navy Laboratory Performance

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ADMINISTRATIVE INFORMATION

The research presented herein is the result of an independent project of the author and designed as partial fulfillment of the requirements for the degree of Doctor of Business Administration. The author presented this project as his dissertation to the graduate faculty of the School of Business and Management, United States International University in San Diego, CA.

Under authority of
John Silva
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ABSTRACT OF DISSERTATION

TECHNOLOGY TRANSFER IN THE NAVY RESEARCH AND DEVELOPMENT COMMUNITY: AN ANALYSIS OF PRIVATE INDUSTRY AND NAVY LABORATORY PERFORMANCE

by

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THE PROBLEM

Effective management of technology is critical to the military defense of the United States. This is particularly true in view of the fact that the Department of Defense is attempting to offset Soviet numerical superiority in most threat areas with superior technology. The key to the success of this strategy is the effective transfer of technology from the nation's research and development laboratories into fielded systems.

The United States Congress has expressed concern over the general health of the Defense Technology Base. One particular concern is the apparently lengthening time required to translate laboratory advances into effective and dependable fielded military systems. Additionally they have expressed significant concern over the quality and value of the technology base efforts of the government owned and operated federal laboratories.

A fundamental problem is the absence of objective, quantitative, output-oriented measures of performance of technology base efforts. This has resulted in an inability to clearly define management actions directed at improving overall effectiveness.

METHOD

→ Within the context of the Navy research and development community, this study sought to evaluate the technology transfer activities occurring between various groups of for-profit and not-for-profit technology providers and technology users. This evaluation was based upon assessments made by technology users of various factors which comprise the technology transfer mechanism.

The explanatory variables in this design constitute ten factors related to perceived technology transfer success. These factors included: documentation, distribution, project, credibility, channel, capacity, linker, willingness, reward, and organization. The design used separate variables to differentiate Navy laboratory and private industry factor performance.

A researcher-designed questionnaire was developed to measure various dependent and explanatory variables. The questionnaire was sent to key technical personnel in Department of Defense organizations which were responsible for, or heavily influenced, the acquisition and implementation of new and innovative technology in Navy equipment and weapon systems.

Naval Research & Development Community (RDC) ←

RESULTS

Various factors in the technology transfer model were found to be significantly related to technology transfer success. Further investigation of the technology transfer process revealed that the importance of

the various factors in the transfer model was not related to the type of technology involved, e.g. process technology versus product technology. Evaluation of the technology transition performance of for-profit versus not-for-profit organizations indicated that, at least in some instances, for-profit private industry was more successful than the not-for-profit Navy laboratories in supplying new and innovative technology.



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CHAPTER 1

THE RESEARCH PROBLEM

Effective management of technology is critical to the nation's defense. This is particularly true in view of the fact that the Department of Defense is attempting to offset Soviet numerical superiority in most threat areas with superior technology. Kerber stated that the key to the success of this strategy is the effective transfer of technology from federal laboratories into Department of Defense systems (American Association of Engineering Societies, 1987).

The application of Management of Technology theory, and methods could provide an effective conceptual framework for maximizing the benefit from federally funded research and development. However, according to the National Research Council (1987), Management of Technology is an emerging field of education and research that is not generally well recognized or even consistently defined. Additionally, there is at present very little systematic attention being paid to Management of Technology issues within the federal agencies.

STATEMENT OF PROBLEM

The United States Congress has expressed concern over the general health of the Defense Technology Base. One particular concern is the apparently lengthening time required to translate laboratory advanced into effective and dependable fielded military systems. In addition they have expressed significant concern over the quality and value of the Technology Base efforts of government laboratories (Office of Technology Assessment, 1988).

The Defense Science Board (1987) concurred in the conclusion that the Department of Defense is seriously deficient in its ability to rapidly transition technology into systems and products, and concluded that the situation is likely to worsen in the future. Specific concern was expressed regarding the manner in which the Navy is organized to transition from technological opportunity to fielded systems, citing that of the three services the Navy has removed its Technology Base management institutions farthest from its procurement institutions.

The absence of objective, quantitative, output-oriented measures of performance of Technology Base efforts additionally results in an inability to clearly define management actions directed at improving overall performance (Defense Science Board, 1987).

PURPOSE OF STUDY

It was the purpose of this study to evaluate the relative quality of technology transfer activities that exist among the various technology providers and technology users which participate in the Navy Research, Development, Test, and Evaluation process.

Research Questions

The research questions addressed by this study were:

1. To what extent do various personal and organizational characteristics influence technology transfer success?
2. Are the effects of these characteristics dependent upon the type of technology involved?

3. What is the relative technology transfer performance of for-profit versus not-for-profit technology supplier organizations?
4. What is the relative technology transfer performance of the various technology user organizations?
5. To what extent is technology implementation success dependent upon the availability of new and innovative technology?
6. What is the relative technology transfer performance of the individual Navy laboratories?
7. What is the relative technology transfer performance of various specific technology areas?

THEORETICAL FRAMEWORK

A technology transfer model as suggested by Creighton, Jolly, and Denning (1972) and others was used in this study to analyze the technology transfer performance of various organizations within the Navy research and development community. This model describes the technology transfer process through the delineation of ten factors which comprise the transfer mechanism. The following is a listing and brief description of each of these ten factors.

1. **Organization**—The organization factor consists of the characteristics of both the formal and informal organization, such as organization structure, managerial climate, make-up of work force, policies, etc, which impact upon the transfer.
2. **Project**—The project factor reflects the responsiveness of the technology developer to potential user needs. It includes consideration of the procedures and standards for selection of new projects, standards of approval, and review system process.
3. **Documentation**—Documentation takes the form of reports, technical notes, drawings, news articles, video tapes, movies, storage systems, etc. Language, timeliness of information delivery, and the clarity of idea expression are important considerations for effective documentation.
4. **Distribution**—This factor represents the physical channel through which technology information flows, involving both the number of entries and ease of access into the channel.
5. **Linked**—The linker represents a person or organization which may exist within or between either the technology supplier or technology user organization. The role of the linker is to convey and disseminate information describing new technology developments.
6. **Capacity**—Capacity represents a wide spectrum of personal and organizational traits, such as education and work load, which influence the movement of information.
7. **Credibility**—Credibility reflects an assessment of the reliability of the information source.
8. **Willingness**—Willingness represents the personal desire of a potential new technology recipient to accept and use new products, processes, or methods.
9. **Reward**—Reward is a motivation for action, or in some cases inaction. The perceived degree of reward, positive or negative, is a cause for action.
10. **Channel**—The Channel factor describes the structure or predictability of the channel used by technology developers to communicate with potential users.

IMPORTANCE OF THIS STUDY

Effective management of technology is critical to this nation's defense, especially in view of the fact that Soviet numerical superiority must be offset with superior technology. The key to the success of this

strategy is the effective transfer of technology from research and development laboratories into fielded Systems. Unfortunately there have been few quantitative studies undertaken to provide the Navy community specific feedback to help better understand this process or identify how well this objective is being achieved.

This study addressed a critical link within the Navy acquisition process, the flow of innovative technology from Department of Defense and industry research and development laboratories to organizations responsible for the design and implementation of new Navy equipment and weapon systems. A full understanding of this process is critical if maximum benefit is to be realized from the research and development product.

SCOPE OF STUDY

This study evaluated the opinions of various technology users regarding the relative quality of technology transfer activities which existed within the Navy research and development community. Data obtained for analysis were based upon assessments made by technical personnel within various technology user organizations, all of which were geographically located in Washington D.C.

This study did not address technology transfer occurring among the various technology provider organizations, including the flow of technology from federally sponsored research to the private sector.

This study did not address the adequacy of the level of technology base resources, but focused on the process for utilizing available resources more effectively and efficiently. This study did not address the technical competence of any of the levels of technology base management.

BACKGROUND OF PROBLEM

Both theoretical and real-world backgrounds must be considered to understand the context of this study. These perspectives are presented in the following sections.

Theoretical Background

The National Research Council (1987) identified several root problems that characterize today's competitive environment and demand more effective techniques for the management of technology. These characteristics include: (1) an exponentially accelerating rate of change in product and process technology; (2) shorter product life cycles; (3) a shortening of product development times; and (4) the invalidation of many traditional management tools and methodologies in the face of these and other changes.

The aim of Management-of-Technology methodologies and techniques is to improve the speed and efficiency of the process by which technology is developed, innovation occurs, and products or systems are produced and brought to the marketplace. Improvements can be realized through integration of the engineering and management disciplines, yielding management tools, techniques and knowledge that can help an organization accomplish its strategic and operational objectives. Management of Technology thus spans the entire research and development spectrum, from basic research to technology utilization and diffusion.

Research efforts in Management of Technology at colleges and universities in the United States are presently limited, fragmented, and uncoordinated. The literature is highly diverse, lacking both a common language and a consensus on the research approaches to be pursued. The body of knowledge needed to provide a comprehensive theory either does not yet exist or a consensus has not been reached. To date,

many partial theories and models have been put forward for testing, and useful results have been obtained, but the focus of the research remains diffused (American Association of Engineering societies, 1987).

Further, Godkin (1988) has reported that the process of technology transfer, a specific area within the Management-of-Technology field, is in a nascent phase of development.

Real-World Background

Past and present national research and development programs have demonstrated an abundance of innovative ideas within the United States scientific and engineering communities and have contributed significantly to our defense systems capabilities. Some improvements have been incremental, others have been major leaps forward in warfighting capability. Examples of steady improvements exist in the areas of materials, propulsion systems, radar and electro-optic sensors, medical, and space technologies. Nevertheless, major opportunities for major advances in the areas of directed energy weapons, remote stand-off weapons, stealth technology, microelectronics and submarine laser communication remain largely untapped.

Addressing the problem of rapid technology transition to fielded system is a primary objective of successful research and development management. However, both the Defense Department and industry are seriously deficient in their ability to rapidly transition technology into systems and products.

This situation is a primary contributor to the growing crisis in military competition as Soviet weapons system performance approaches and, in some cases, exceeds that of the United States. Because we can anticipate general numerical inferiority to Eastern Bloc and other potentially hostile forces, conflict outcomes with these forces could be disastrous for the United States unless this situation is reversed or otherwise offset by technology. The greatest opportunity to improve this situation is to accelerate the transition of technology to existing or emerging systems (Defense Science Board, 1987).

The following sections present and discuss the process by which the Navy transforms new technology into deployed systems and equipments. In addition the various groups and organizations which actively participate in this process are categorized and described.

The Navy Research, Development, Test, and Evaluation Process. Figure 1 presents a functional view of the process by which the Navy transforms innovative new technology from initial concepts and ideas into fielded equipments and systems. This multistage information generation and conversion methodology is referred to as the Defense Research, Development, Test, and Evaluation process.

The first step of this process, 6.1 Research, represents the development of a store of knowledge which is generated by research in understanding and defining the laws of nature, providing fundamental knowledge upon which the further development of a new technology may be pursued.

The second stage, 6.2 Exploratory Development, represents effort that may vary from applied or targeted research to the fabrication of prototype hardware. The dominant characteristic of effort in this category is the development and evaluation of the feasibility and practicability of new technological concepts.

The knowledge, skills, capabilities, and facilities associated with the collective efforts of these first two stages constitute the Defense Technology Base (Office of Technology Assessment, 1988).

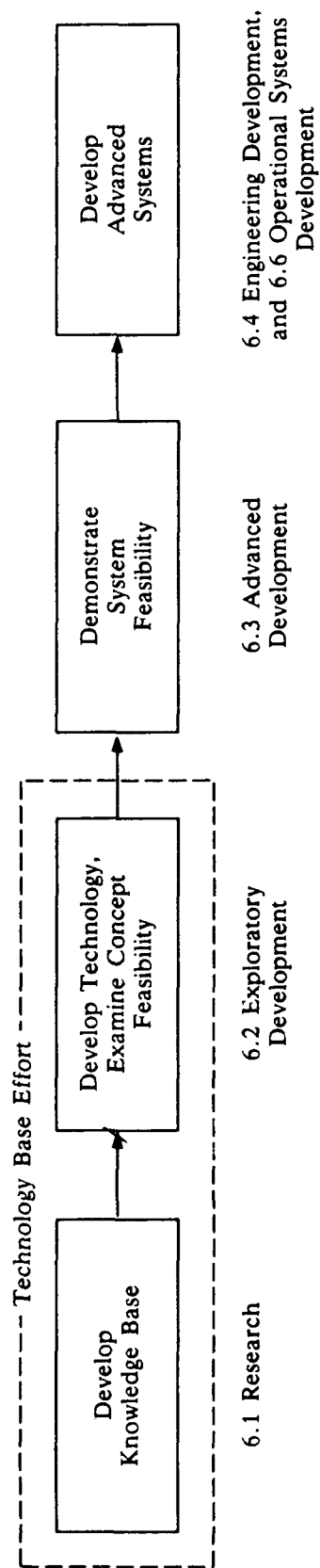


Figure 1. Functional view of the Navy research, development, test, and engineering process.

The demonstration of system feasibility provides proof of the design concept and comprises the efforts in the third stage, 6.3 Advanced Development. This stage involves experimentally demonstrating the feasibility and construction of the technology. The major product is proof of the advantage to be gained through the application of new technology, as well as a clearer recognition of any adjunct technology that may be required to implement an advanced system.

The fourth and last stage of the Research, Development, Test, and Evaluation process includes the functions of 6.4 Engineering Development and 6.6 Operational Systems Development. These functions support the production engineering and actual procurement of system hardware that will be used by the Navy.

The Navy Research and Development Community. Figure 2 depicts the major groups and organizations which comprise the Navy research and development community. These organizations can be generally divided into two major categories: (1) technology providers who conduct or perform research and development effort; and (2) technology users who are responsible for the incorporation of research and development products in new systems and equipments.

1. Technology providers are generally responsible for execution of the 6.1 Research and 6.2 Exploratory Development stages in the Research, Development, Test and Engineering process. These groups and organizations which provide technology through the performance of research and development efforts can be further subdivided into two general classes, in-house and out-of-house performers. The principal in-house performers are government-owned, government-operated laboratories.

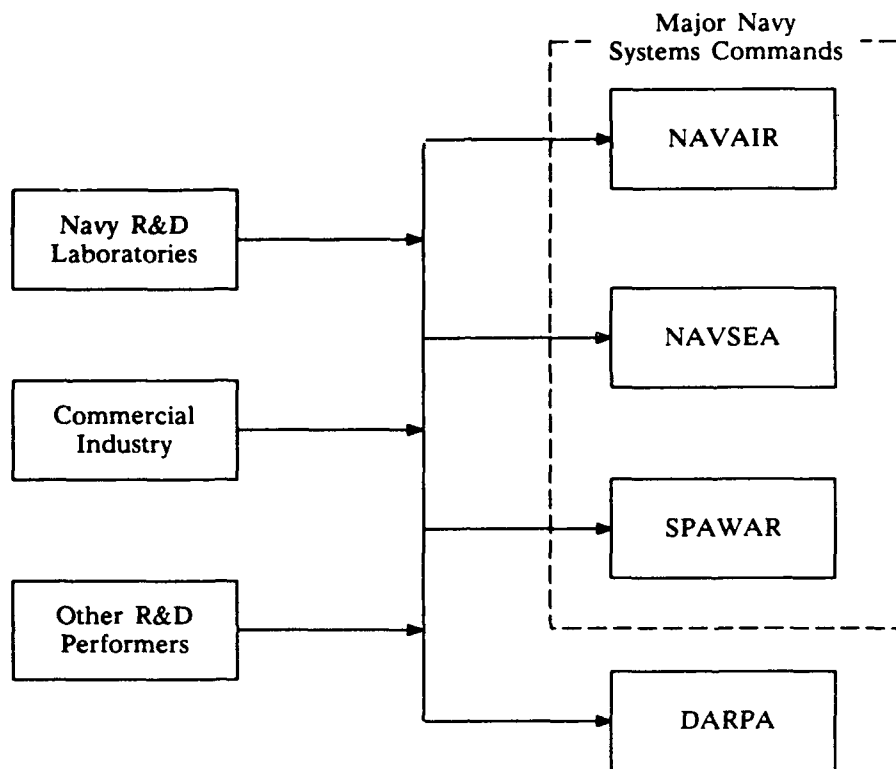
These Navy in-house laboratories are the principal repository of corporate scientific and technological expertise. This expertise is developed and maintained primarily through the execution of Research and Exploratory Development programs. The technical staffs of these laboratories provide a source of advice and consultation available to all Department of Navy managers. The availability of this base of in-house technical competence is essential to protect the government against a situation where outside technical advice (i.e. from private industry contractors) becomes *de facto* technical decision making.

The Navy's in-house research and development laboratories today employ over 17,000 scientists and engineers, representing an annual workload of more than \$4.4 billion dollars (U.S. Department of the Navy, 1987).

For-profit private industry contractors constitute the primary out-of-house research and development performer for the Navy. Such efforts are either funded directly by contract or supported by Independent Research and Development grants from the federal government. Additionally, educational and other not-for-profit institutions whose primary purpose is to conduct fundamental scientific research are also categorized as out-of-house performers of Navy research and development.

Other non-Navy government organizations such as the National Aeronautics and Space Administration (NASA), Army, Air Force, and National Institute of Standards and Technology (formerly the National Bureau of Standards) also conduct limited Navy research and development and are additionally considered out-of-house technology providers.

2. Technology users are generally responsible for execution of the Advanced Development, Engineering Development, and Operational Systems Development stages in the Research, Development, Test, and Engineering process. Primary responsibility for the incorporation of research and development products in new Navy systems and equipment resides within three major Navy Systems Commands: the Space and Naval Warfare Systems Command



Legend:

NAVAIR—Naval Air Systems Command
NAVSEA—Naval Sea Systems Command
SPAWAR—Space and Naval Warfare Systems Command
DARPA—Defense Advanced Research Projects Agency

Figure 2. Technology flow in the Navy research and development community.

(SPAWAR), the Naval Sea Systems Command (NAVSEA), and the Naval Air Systems Command (NAVAIR). As such these organizations draw heavily upon the research and development results of numerous Department of Defense and industry organizations.

In addition to the above Navy specific organizations the Defense Advanced Research Projects Agency (DARPA) has begun playing an increasingly influential role in the design of future Navy systems. A recent example of this influence has been the Congressionally mandated responsibility for the conceptual development of an advanced next-generation submarine.

The Defense Advanced Research Projects Agency is a separately organized operating research and development agency of the Department of Defense under the direction and supervision of the Assistant Secretary of Defense, Research and Technology. Its broad charter includes responsibility for basic and applied research and development for such advanced projects as may be designated by the Secretary of Defense.

The Technology User/Technology Supplier Dialog. The technology user is primarily responsible for determining needs to be done while the technology supplier is primarily responsible for determining results can be achieved. Together through a dialog in which the User is spokesman for demand and the Supplier for supply, a compromise is reached between what is desirable and what is possible.

The roles of User and Supplier are relative. One individual or organization may function as User in one relationship and as Supplier in another, or may function as both. For example the Defense Advanced Research Projects Agency is both a Supplier of technology through their sponsorship of Technology Base effort, and a User of technology in their system design and prototyping efforts.

DEFINITIONS

This section provides definitions for some of the terminology used to describe the context of this study. Many of the definitions describe the various organizations that were either directly or indirectly involved in this study, as well as their relationships and unique characteristics.

Naval Systems Commands

The Naval Systems Commands provide for and meet the material support needs of the Department of the Navy. These responsibilities include the design, development, logistics planning, test, technical evaluation, acquisition, maintenance, and repair of Navy material and equipment. The major system Commands are the Naval Air Systems Command, Naval Sea Systems Command, and the Space and Naval Warfare Systems Command.

In-House Research Development Laboratories

The in-house Navy laboratories provide technical competence needed by the Federal government to develop, acquire, and maintain military capabilities needed for national security. These government-owned, government-operated facilities operate under the Navy Industrial Fund accounting system. Major facilities include the David Taylor Research Center, Naval Air Development Center, Naval Civil Engineering Center, Naval Coastal Systems Center, Naval Personnel Research and Development Center, Naval Research Laboratory, Naval Surface Warfare Center, Naval Training Systems Center, Naval Underwater Systems Center, and Naval Weapons Center.

Navy Industrial Fund

The Navy Industrial Fund is a cost reimbursement form of accounting system used to conduct financial transactions wholly within various government organizations. Navy Industrial Funds provide a

revolving type of working capital for each in-house activity. Funds expended for labor, material, and overhead are replenished by receipts from periodic billings to customers. It is the goal of this budgeting process to break even, that is generate no profit nor incur any loss.

Technology Provider

An organization whose primary mission includes the discovery and development of new scientific knowledge.

Technology User

An organization who uses new scientific knowledge to design systems and equipments which possess improved performance characteristics and capabilities.

Technology Push/Requirements Pull

The concepts of technology push and requirements pull are related to the relative influence of supply, equated to technology push, and demand, or requirements pull, on the formulation of research and development programs. Technology push represents the pursuit of what is technologically feasible. Requirements pull represents needs to be achieved, with the impetus to solve problems which will allow the attainment of needed operational capabilities.

SUMMARY

Effective management of technology is critical to the defense of the United States, particularly in view of the fact that the Department of Defense is attempting to offset Soviet numerical superiority with superior technology. The key to the success of this strategy is the effective transfer of technology from federal laboratories into fielded systems.

However, both the Defense Department and private industry are seriously deficient in their ability to rapidly transition technology into systems and products. This situation is expected to become worse in the future as many traditional management tools and methodologies become invalid in the face of the rapid changes taking place in today's competitive environment (Defense Science Board, 1987).

The application of Management-of-Technology theory and methods provides an effective conceptual framework to aid the understanding of the relationships and processes in this new environment. This study supported the further development of the emerging field by evaluation of the relative quality of technology transfer activities that exist among the various technology providers and technology users that participate in the Navy development and acquisition process.

CHAPTER 2

REVIEW OF LITERATURE

This study compared the technology transfer performance of for-profit industry with a group of federally funded not-for-profit organizations. This evaluation took place within the context of the Navy's research and development community. The existing literature regarding technology transfer, a topic within the Management-of-Technology field, and behavioral and performance differences between for-profit and not-for-profit organizations was reviewed.

TECHNOLOGY TRANSFER AND THE MANAGEMENT OF TECHNOLOGY

The National Research Council (1987:9) defined management of technology as: "...the linking of engineering, science, and management disciplines to plan, development and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization." The council pointed out that although management of technology has existed as a limited field for at least 25 years, it had not attained the status of a recognized discipline, but rather is viewed as an emerging interdisciplinary field.

The American Association of Engineering Societies (1987) stated that the need to manage technology effectively is not a new phenomenon. They identified a number of features of the current competitive global environment that demanded improved technology management techniques. These features included the accelerating rate of change in new product and process technology; shorter product life cycles; shorter product development times worldwide; and the invalidation of many traditional management tools and methodologies in the face of these and other changes.

The Task Force on Management of Technology (1987:7) proposed that a growing number of managers are beginning to recognize that the problem of effective technology management may be due to an inability to quantitatively evaluate results, as well as to present-day shortcomings of traditional management approaches. They pointed out that "There are few principles to follow, few examples to emulate and that development of new approaches typically involves an expensive process of trial and error...."

Teece and Winter (1984) suggested that management miseducation may be the cause of the productivity slowdown and competitive difficulties off American firms, citing reports of over-utilization of techniques that deflect attention from long-run technological development to financial control and portfolio management. A survey of MBA curriculums at leading business schools found only 12 percent of MBA students were even modestly exposed to technological innovation management. The authors suggested that an increased emphasis should be placed upon understanding the dynamics of economic theory, and the production and utilization of technological knowledge.

Technology Transfer

The National Research Council (1987) identified technology transfer as one of ten specific areas delineating the Management-of-Technology field. Upon review of the literature describing technology transfer, Godkin (1988) reported it, in general, to be in a nascent phase of development.

Teece (1977) developed a model to explain the costs of horizontal technology transfer for multinational organizations. Data on 17 chemical and petroleum refining, and 9 machinery international

technology transfer projects were analyzed. All firms were headquartered in the United States. Analysis of the data indicated that transfer costs decline as the number of firms with identical or similar technology increases, and as the experience of the transferee increases. The author noted that the cost of transferring chemical and petroleum refining technology was relatively low, presumably because it was possible to embody sophisticated process technology in capital equipment, which in turn facilitated the transfer process. There was evidence that transfers to governments in centrally planned economies involve substantial extra costs, possibly because of high documentation requirements, or differences in language and managerial procedures.

The author defined horizontal transfer as the transfer of technical information from one project to another. Vertical transfer refers to the transfer of technical information within the various stages of a particular innovation process, e.g. from the basic research stage to the applied research stage.

The Technology Transfer Process. The Directory of Federal Technology (1975:v) defined technology transfer as "...the process by which existing research is transferred operationally into useful processes, products, or programs that fulfill actual or potential public or private needs."

Grubber (1976) emphasized the dynamics of this process by stating that technological change and innovation occur as the result of a complex set of human interactions, information flows and transfers, individual and organizational creativity, risk-taking and decision-making.

Dorf (1988) described the commercialization of new technology as being less like a relay race where runners sequentially hand off a baton, but more like a basketball game where players pass the ball back and forth as they advance towards the goal.

Technology Diffusion. Jolly, Creighton and George (1978) defined technology diffusion as the unplanned movement of information from a source to a user. They pointed out that this process is quite slow and cited studies which have shown that it may take as long as 30 years for a new technology to permeate an industry on a world-wide basis. Godkin (1988) stated that reliance upon diffusion of innovation is proving to be inadequate, that the process is unpredictable, and is slow to speed the application of new technology.

Talaysum (1985) stated that implications of diffusion-related findings have not been well analyzed from a managerial perspective. Following a survey of the literature concerning diffusion-mode technology transfer from universities to industry, Boyle (1986) concluded that the majority of papers are anecdotal and that there is a general lack of empirical research. A number of universal modeling approaches were commonly used which do not apply in specific circumstances, and there were few in-depth case studies and one-industry studies to account for uniqueness in each operating environment. Properly, many related papers use the source of technology as the unit of analysis. Relatively few researchers have focused on industry as the recipient of new technology.

Weijo (1987) described technology diffusion as a user-driven, demand-pull approach to technological innovation. The process starts with an identified need in the marketplace and works toward the necessary technology which provides an effective and efficient solution to the problem. The technology source organizations do not attempt to thoroughly understand the market need for a technological innovation, their goal is simply to further scientific knowledge. Thus their role in the diffusion process is limited to making such technology information available.

Mogavero and Shane (1982) referred to the diffusion process as the passive mode of technology transfer. They noted that familiar and widely used forms of passive technology transfer include the cookbook, automobile repair manual and how-to-do-it guide for home repair. The authors note no one-on-one communication takes place between the originator of the knowledge and the end-user. They point out that in this mode of information transfer a presumption is made that the user possesses an elementary familiarity with, and competence in the subject.

Dorf (1988) pointed out that the diffusion model is based upon the premise that the potential recipient would use the technology if he were aware that the technology existed, pointing out that awareness of the availability of such information is critical to its transfer.

Semiactive and Active Modes of Technology Transfer. Mogavero and Shane (1982) also described semiactive and active modes of technology transfer. The semiactive mode differs from the self-education and self-retrieval of technology information due to the intervention of a knowledge or technology transfer agent. This agent screens available pertinent information to eliminate redundancy and unnecessary information. Additionally the agent may detect and eliminate erroneous information, as well as material that has only limited applicability. What the transfer agent transmits is a body of manageable data. The authors note that in the semiactive mode the agent has not gone beyond the role of a communicator, and has not actively participated in the application of the technology.

The active mode of technology transfer carries the process through to an actual technology demonstration. This form of communication of technological information recognizes that words or written descriptions alone may not sufficiently communicate the ideas, only a model actually demonstrating the technology that is being transferred will suffice. Moreover, the finished working model may not be enough, it may be further necessary to show the various steps of the construction of the model from procurement of materials to fabrication and assembly of the parts that embody the technology being transferred: In this mode the transfer agent is no longer merely supplying information as in the semiactive mode, but is a technologist who is actively searching for the solution to an identified problem.

Weijo (1987) described the semiactive and active modes of technology transfer as a source-driven, technology-push process because the transferring agency is aggressively attempting to reach a designated target audience. The technology-push approach begins with an innovative technology and works toward the identification of need in the marketplace. Weijo also identified several factors to aid in the selection of which mode, or modes of technology transfer to adopt.

Essoglou (1975) further developed the role of the transfer agent, or linker, by addressing his organizational alignment in Mogavero and Shane's source-linker-user model. He pointed out that the linker may belong to the source organization, to the user organization, or may be independent and organizationally separate from either. He could be a private entrepreneur or be funded by the public sector to perform the technology transfer function.

Creighton, Jolly and Denning (1972) studied and categorized various behavioral characteristics of individuals to determine if they they possessed linker or stabilizer traits.

Wolf (1984) presented a nine step *modus operandi*, or action plan, for improving linkage agent performance. He drew an analogy of his methodology to a roadmap specifying a starting point, alternate routes, and a destination. The nine step methodology allowed an agent to plan a linkage strategy, modify the strategy in light of new information, and to later critique the tactics used to achieve the information transfer.

Beasley emphasized the importance of the linker role by stating "Technology transfer is a body contact sport. And, we therefore need to increase the contact between the people who are worrying about the applications and the people who are doing the science." (Race for the Superconductor, 1988).

Weijo (1987) pointed out the importance of boundary-spanning roles to innovation success and defined the three most important such roles as technical, marketing, and manufacturing.

The linker is alternately referred to in the literature as the change agent, transfer agent, technology gatekeeper, liaison agent, innovator, or opinion leader. (Creighton et al., 1984).

A Paradigm of Technology Transfer

Karagozoglu and Brown (1986) addressed technology transfer from a macro-perspective. Their multi-level, multiphase model accounts for the interactive influences of government, industry, technology base, and economic forces on the technology transfer process in a given country.

Creighton, Jolly and Denning (1972) developed and described a micro-level model of information transfer. In their initial work a review of the literature on the movement of information revealed many models in existence. Further examination of these models revealed that the majority were after-the-fact success descriptions, and generally described step-by-step activities rather than providing fundamental concepts.

The complexity and difficulty in using these models led Creighton and Jolly toward the development of a model of information transfer that would encompass the key elements of these various procedural models. As a result of this effort a list of nine fundamental elements or factors evolved which appeared to include all the functional activities. As such it is not primarily an analytic model, but more a paradigm of significant factors which compose the transfer mechanism.

Their model, referred to as the Predictive Model of Technology Transfer and depicted in Figure 3, is divided into formal and informal factors. Formal factors are procedural, meaning they are generally governed by some course of action or set of rules established by the organization. Informal factors are the interpersonal or behavioral characteristics of the individuals. A brief description of each of these factors or elements follows.

Formal Elements:

1. **Organization**—The organization factor consists of the characteristics of both the formal and informal organization, such as organization structure, managerial climate, make-up of work force, policies, etc, which impact upon the transfer.
2. **Project**—The project factor reflects the responsiveness of the technology developer to potential user needs. It includes consideration of the procedures and standards for selection of new projects, standards of approval, and review system process.
3. **Documentation**—Documentation takes the form of reports, technical notes, drawings, news articles, video tapes, movies, storage systems, etc. Language, timeliness of information delivery, and the clarity of idea expression are important considerations for effective documentation.

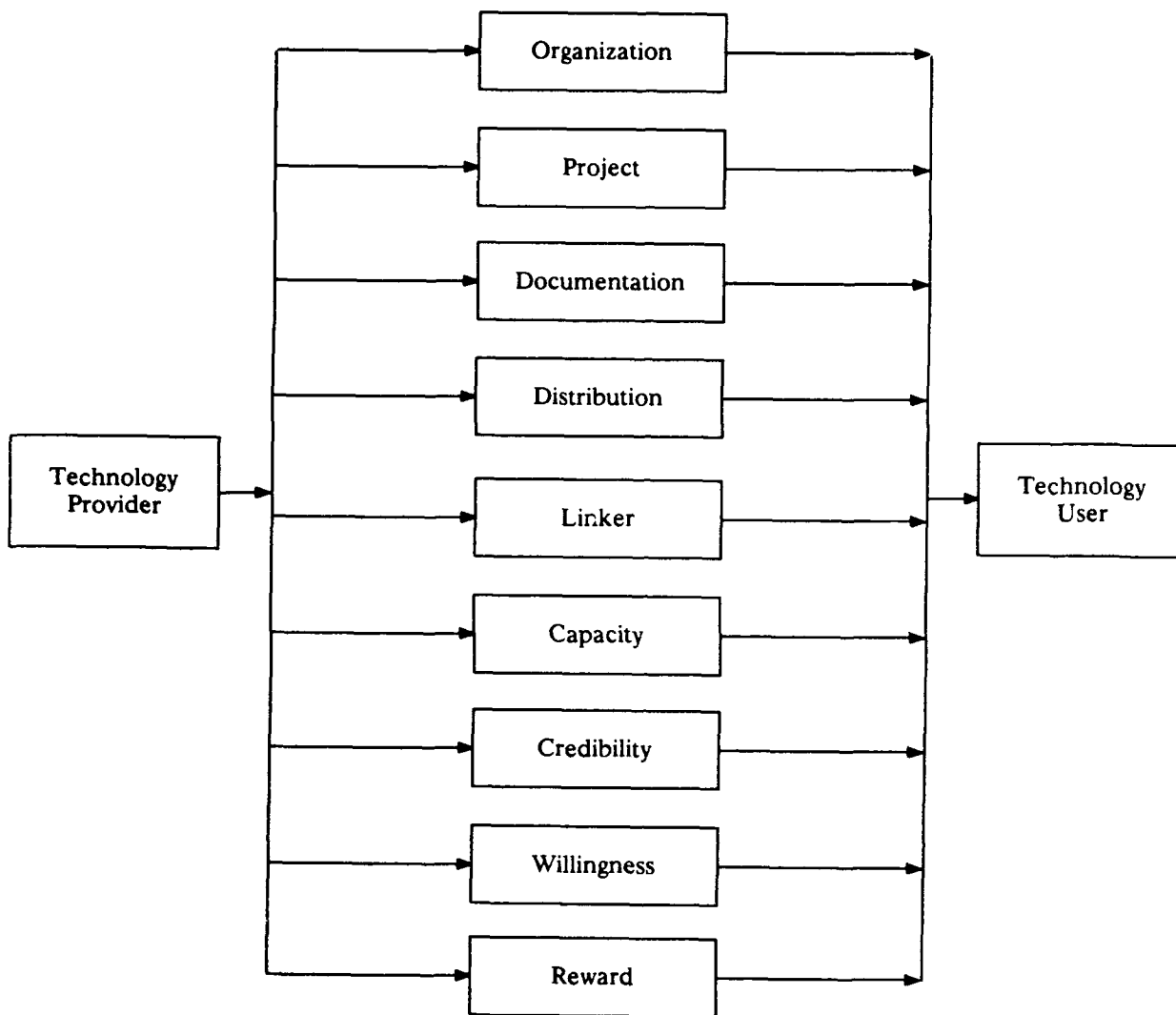


Figure 3. Predictive model of technology transfer
(Creighton, Jolly, and Denning, 1972)

4. **Distribution**—This factor represents the physical channel through which technology information flows, involving both the number of entries and ease of access into the channel.

Informal Elements:

5. **Linker**—The linker represents a person or organization which may exist within or between either the technology supplier or technology user organization. The role of the linker is to convey and disseminate information describing new technology developments.
6. **Capacity**—Capacity represents a wide spectrum of personal and organizational traits, such as education and work load, which influence the movement of information.
7. **Credibility**—Credibility reflects an assessment of the reliability of the information source.
8. **Willingness**—Willingness represents the personal desire of a potential new technology recipient to accept and use new products, processes, or methods.
9. **Reward**—Reward is a motivation for action, or in some cases inaction. The perceived degree of reward, positive or negative, is a cause for action.

The authors point out that it should be understood that these factors are interactive. For example documentation is useless unless the document is distributed. Interaction of the elements is particularly important considering the entire process of technology movement is likely to involve all nine elements.

Empirical Studies

Rohrer and Buckles (1980) reviewed the findings of twenty-four researchers at the Naval Postgraduate School, Monterey which directly supported one or more of the elements of the Predictive Model of Technology Transfer. Their purpose was to determine the degree and extent of research related to each of the model's nine elements. They concluded that the distribution of research effort has not been uniform and identified several of the nine model elements requiring future emphasis.

They also reviewed the findings of twenty-two researchers on the measurement of effectiveness of three independent federal programs designed to enhance the use of research output.

Morck (1984) investigated the information transfer process between managers and researchers in managing federal outdoor recreational resources. The study focused on how managers actively gather information and the role of personal and organizational variables in the information transfer process. The approach this study took to analyze this process is grounded in Creighton and Jolly's Predictive Model of Technology Transfer.

FOR-PROFIT VERSUS NOT-FOR-PROFIT ORGANIZATIONS

The similarities and differences between the behavior and performance of for-profit business firms, and various types of not-for-profit organizations is the subject of much conflicting literature. Reviews of both of these perspectives are presented.

Similarities

There is a large volume of literature that supports the belief that for-profit and not-for-profit organizations are in many ways similar. A common perspective behind many of these explanations is that the complexity of our business environment has grown to a point where it has overshadowed the single dimension of a business' legal status.

Rainey, Backoff and Levine (1976) suggested that public and private organizations are converging and facing similar constraints and challenges, and that management in all types of organizations should be viewed as a generic process. They suggested that coping with environmental turbulence will become such a major concern that any differences will be overshadowed.

Bozeman (1987) noted that "sector blurring" is becoming as much the rule as the exception, and that new organizational forms are emerging that are not easily classified by conventional labels. An example given was Oak Ridge National Laboratory, a government-owned contractor-operated organization managed by the Department of Energy. He noted that generic organizational theory equates public to government.

In a study of 829 research and development organizations classified by traditional legal status for public-private distinction, and a measure of publicness which was based upon percentage of government, as opposed to private, financing, the author noted only 40 percent of the organizations could be clearly labeled as specifically either public or private.

In a study of 32 research and development organizations the author noted that organizational effectiveness in the production of generic, or non-market oriented products, increases as government influence (degree of publicness) increases. Effectiveness in the production of market oriented research and development increases as privateness increases, regardless of the legal status of the organization. The author proposed that a taxonomy of level of publicness, ownership, and market focus would provide a better understanding of organizational effectiveness.

Strausman (1981), citing experiences in refuse collection, proposed that market mechanisms of price, choice, and competition can be used to curb expenditure growth and to stimulate improved public sector performance.

Birnbaum (1985) conducted a study of 41 medical electronics manufactures, plus the top 100 private and top 100 public research universities. His conclusions suggested a convergence among regulated organization decision makers in their preferred influence strategies for dealing with the regulatory agencies. He further found organizational size is significant in explaining information strategies, rather than the public or private dimension of ownership.

Bruce, Blackburn and Spelsberg (1985) conducted a study of the organizational responsiveness of 45 public and private organizations using a field simulation methodology. They hypothesized that public organizations would not be as responsive because they are not directly affected by market pressures. The results showed no significant differences in responsiveness scores between the different types of organizations.

Differences

There is also a considerable body of literature that attempts to explain the differences in behavior and performance between for-profit and not-for-profit organizations. Such explanations are commonly based upon the existence of the direct and quantifiable feedback provided to for-profit organizations by the marketplace.

Cyert and March (1963) pointed out that firms have profit, sales, inventory and production goals, and that they receive information feedback on these goals, on costs, and on competition behavior. Not-for-profit firms may or may not have analogs of such specific dimensions, depending on the relevance of more general concepts. The authors identify specific differences between political and nonbusiness organizations, and for-profit firms including: 1) the mythology surrounding them, 2) the character of their

Not-for-profit firms may or may not have analogs of such specific dimensions, depending on the relevance of more general concepts. The authors identify specific differences between political and nonbusiness organizations, and for-profit firms including: 1) the mythology surrounding them, 2) the character of their relations with external control groups, and 3) in the traditions surrounding their standard operating procedures.

Ring and Perry (1985) stated that strategic managers in the private and public sectors operate in different contexts that generate distinctively different constraints, and that the criteria for evaluation may differ markedly. They concluded that public sector managerial behavior different from that usually prescribed for private sector managers may be required.

They noted that in the public sector: 1) policy formulators are not policy implementers, 2) public employees are not entirely dependent on the good graces of political bosses for employment, rewards or advancement, and 3) public sector managers are more open to the external environment.

Newman and Wallender (1978) discussed the wide differences among not-for-profit enterprises, pointing out that each has its own managerial needs and constraints that will sharply modify business management concepts.

In a pilot study of 22 not-for-profit enterprises, the authors found: 1) service was intangible and difficult to measure, 2) customer influence was weak, 3) resource contributors intruded into internal management, 4) there were restraints on the use of rewards and punishments, and 5) charismatic leaders and/or mystique of the enterprise were important in resolving conflict in objectives and overcoming restraints.

Buchanan (1974) noted that there is considerable evidence to suggest that business organizations are more successful at stimulating *personal commitment than government agencies*. In a study of 279 managers in three industrial and five federal agencies on job satisfaction and organizational commitment, he found significantly more satisfaction and commitment in industry. He suggested that managers whose efforts make real contributions to organizational success are more likely to develop a deeper commitment. He pointed out that generally public managers have fewer chances to directly verify their contributions toward agency success.

Ott (1980) stated that it is a common view of journalists and academicians that 1) government production uses too many resources relative to its output, and 2) government production yields an output vector whose elements are too large relative to the forgone output of alternative services. He noted the stark contrast to the efficiency of supply functions in the private sector.

Ott theorized this efficiency results from competition amongst firms which is brought about by linking management compensation with firm profitability. He pointed out both profit and the linkage to compensation are missing in public production. Ott further postulated that the salary of the bureaucrat is determined by his operating budget.

Perry and Porter (1982) presented a four element classification system on which to better understand the motivational context of public organizations. The elements included 1) individual characteristics, 2) job characteristics, 3) work environment characteristics, and 4) external environment characteristics. They found that government middle managers had higher needs for achievement and lower needs for affiliation. Additionally students about to enter the nonprofit sector valued economic wealth to a lesser degree than entrants to the for-profit sector.

They noted that government is perceived primarily as a service provider rather than a goods producer, and that the problems of creative performance criteria and implementing evaluation schemes are complex

offers no analogous set of rewards. Managers are rewarded based upon expanded budgets and increased number of personnel supervised, not on more efficient operation. Cost accounting systems are generally either nonexistent or restricted to a few functions. Civil service systems prevent differential treatment and rewards for varying levels of employee performance, and possess an unacceptably elongated hiring process.

THIS STUDY

This study provides an empirical evaluation of the comparative technology transfer performance of for-profit and not-for-profit organizations. This evaluation was conducted within the context of the Navy research and development community. The basis for this evaluation was a technology transfer model as suggested by Creighton, Jolly, Denning and others.

This evaluation addressed technology transfer occurring in the middle ground of the research and development spectrum, that is between targeted research, exploratory development, and advanced development. This area has been identified by Burte as one in particular need of study because it is where the least amount of attention has been focused in the past (American Association of Engineering Societies, 1987).

In addition, this evaluation focused on the recipient, or user, of new technology, an area identified by Talaysum (1985) and Essoglou (1980) as needing further study.

There is considerable conflicting literature addressing both the similarities and differences in the behavior and performance of for-profit and not-for-profit organizations. Bozeman (1987) has proposed an alternative to the conventional for-profit versus not-for-profit taxonomy. Under his classification system based upon degree of publicness, ownership, and market focus the technology source organizations compared in this study would possess a high degree of similarity.

Scientific knowledge, which is the product of research and development organizations, is difficult to quantify. Thus the distinctions between for-profit and not-for-profit organizations which were based upon the existence of directly quantifiable measures, as presented by Cyert and March (1963), Newman and Wallender (1978), and Ott (1980) may not be applicable in the context of this study.

In summary, this study provides an empirical evaluation that integrates theory in the research areas of technology transfer and for-profit versus not-for-profit organizations. Figure 4 shows the classification of relevant literature supporting this study.

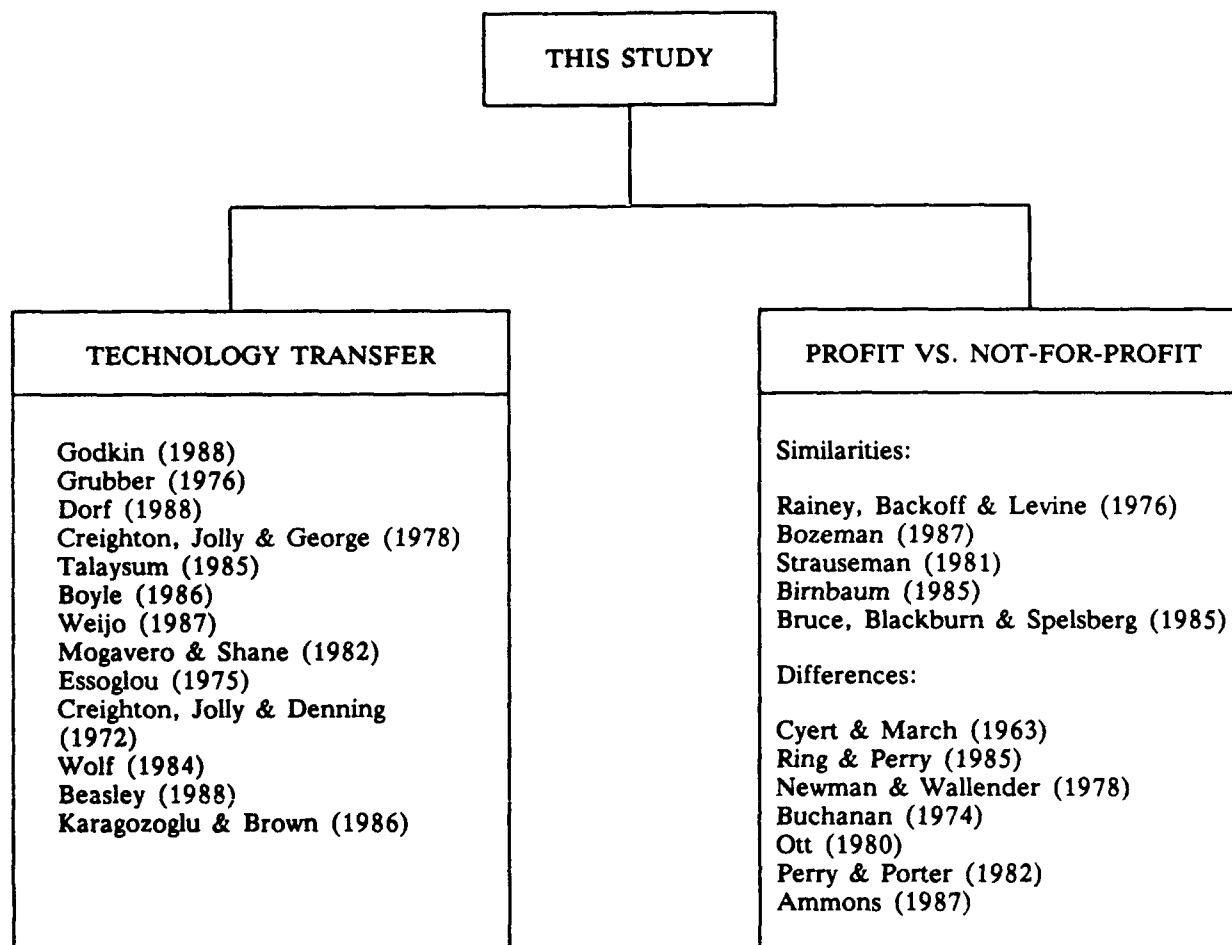


Figure 4. Literature supporting this study.

CHAPTER 3

METHOD

This chapter describes the methods and procedures used to collect and analyze the data presented in this study. A researcher-designed instrument was used to collect information regarding the flow of innovative technology within the Navy research and development community. Approximately 750 questionnaires were mailed to four major Department of Defense organizations. Each of these organizations is responsible for, or strongly influences, the use of new and innovative technology in Navy equipment and weapon systems.

RESEARCH QUESTIONS

Three primary research questions were addressed by this study. The first research question addressed the extent to which various personal and organizational characteristics were related to technology transfer success. The second research question addressed whether there was a relationship between these characteristics and the type of technology involved. The third research question sought to compare the relative technology transfer performance of for-profit versus not-for-profit technology supplier organizations.

Working Hypotheses

These research questions were tested by working hypotheses to examine the above relationships. The following sections describe the working hypotheses.

Technology Transfer Hypotheses

Possible relationships between technology transfer performance and various factors as suggested by Creighton, Jolly, Denning and others were tested by the first ten working hypotheses. These working hypotheses follow.

Working Hypothesis 1. There is a positive relationship between success in technology transfer and the availability of clear documentation describing the new technology which is in a format and at a level of detail appropriate to the technology users' needs. This variable is termed Documentation.

Working Hypothesis 2. There is a positive relationship between success in technology transfer and the technology user's ease of access to needed technical documentation and information. This variable is termed Distribution.

Working Hypothesis 3. There is a positive relationship between success in technology transfer and the consideration by the technology developer of the potential user's technology needs. This variable is termed Project.

Working Hypothesis 4. There is a positive relationship between success in technology transfer and the technical credibility and reliability of the organization developing the new technology. This variable is termed Credibility.

Working Hypothesis 5. There is a positive relationship between success in technology transfer and the use of repeatable and well-defined channels of communication between the technology provider and technology user. This variable is termed Channel.

Working Hypothesis 6. There is a positive relationship between success in technology transfer and the presence of personnel in the technology user organization who possess the education, skills and traits necessary to seek out and implement innovative technology. This variable is termed Capacity.

Working Hypothesis 7. There is a positive relationship between success in technology transfer and the presence of personnel in the technology user organization who frequently discuss new and innovative technology developments. This variable is termed Linker.

Working Hypothesis 8. There is a positive relationship between success in technology transfer and the presence of personnel in the technology user organization who actively seek new and innovative solutions to system performance requirements. This variable is termed Willingness.

Working Hypothesis 9. There is a positive relationship between success in technology transfer and the occurrence of promotions for personnel in the technology user organization who pursue new ideas, processes or products. This variable is termed Reward.

Working Hypothesis 10. There is a positive relationship between success in technology transfer and the presence of organizational support for the investigation and use of new and innovative technology. This variable is termed Organization.

Technology Dependence Hypothesis

The second primary research question addressed the possible relationships between the various factors identified in the Technology Transfer Hypotheses and the type of technology involved in the transfer.

Seven diverse types of technology were identified to provide a broad spectrum of technology categorizations. These categorizations provided a segmentation based upon various technology attributes, including for example product versus process technology. The seven categorizations used included:

1. Computer Technology—including computing power/modeling, software engineering, cooperative engagement technologies, information management and decision-making, and simulation technology.
2. Software Technology—including software engineering and information management and decision-making.
3. Command, Control, and Communications Technology—including cooperative engagement technologies and space-based systems.
4. Fiber optics and Photonics Technology—including fiber transmission lines, optical sources, sensors and components.
5. Advanced Sensor Technology—including transducers and electromagnetic devices, and navigation sensors.
6. Space-based System Technology—including communications, surveillance, and data processing.
7. Autonomous Vehicle Technology—including guidance and control, automatic targeting, intelligent subsystems, and telecommunications.

The Technology Dependence Hypothesis was tested by the following working hypothesis.

Working Hypothesis 11. There is no relationship between the regression coefficients for the explanatory variables identified in the Technology Transfer Hypotheses and the type of technology involved in the transfer.

Financial Dependence Hypotheses

The third research question addressed the relative technology transfer performance of for-profit technology suppliers, as represented by private industry, versus not-for-profit technology providers, as represented by the Navy laboratories. This research question was tested through the following working hypotheses.

Working Hypothesis 12. There are no differences between Navy laboratories and private industry in the means of the frequency of the following technology transfer factors: Documentation, Distribution, Project, Credibility, and Channel.

Working Hypothesis 13. There are no differences among the evaluating organizations in the means of the frequency of the following Navy laboratory and private industry technology transfer factors: Documentation, Distribution, Project, Credibility, and Channel.

Working Hypothesis 14. There are no differences between Navy laboratories and private industry in the means of the frequency of success in providing innovative technology to meet new system performance requirements.

Working Hypothesis 15. There are no differences among the evaluating organizations in the means of the frequency of Navy laboratory and private industry success in providing innovative technology to meet new system performance requirements.

Other Hypotheses—Technology User Differences

Other working hypotheses were also formulated to provide a further understanding of the technology transfer process within the Navy research and development community. The first of these hypotheses explored potential differences among the responding organizations which could effect technology transfer performance. The following working hypotheses address these possible differences:

Working Hypothesis 16. There are no differences among the respondent organizations in the means of the frequency of the following technology transfer factors: Capacity, Linker, Willingness, Reward, and Organization.

Working Hypothesis 17. There are no differences among the respondent organizations in the means of the frequency of success in acquiring and implementing new and innovative technology.

Other Hypotheses—Technology User Dependence

The relationship between technology provider success in supplying innovative technology and technology user success in acquiring and implementing new and innovative technology was tested by the following working hypotheses:

Working Hypothesis 18. There is a positive relationship between Navy laboratory success in providing innovative technology and respondent organization success in acquiring and implementing new and innovative technology.

Working Hypothesis 19. There is a positive relationship between private industry success in providing innovative technology and respondent organization success in acquiring and implementing new and innovative technology.

Other Hypotheses—Individual Navy Laboratory Performance

This study also sought to determine the technology transfer performance of individual Navy laboratories. The specific working hypotheses follow.

Working (Null) Hypothesis 20. There is no difference in the performances of the individual Navy laboratories in terms of the reported frequency of the following technology transfer factors: Documentation, Distribution, Project, Credibility, and Channel.

Working (Null) Hypothesis 21. There is no difference in the performances of the individual Navy laboratories in terms of the importance of their contributions toward overall Navy laboratory performance for the following technology transfer factors: Documentation, Distribution, Project, Credibility, and Channel.

Working (Null) Hypothesis 22. There is no difference in the performances of the individual Navy laboratories in terms of success in providing innovative technology to meet system performance requirements.

Working (Null) Hypothesis 23. There is no difference in the performances of the individual Navy laboratories in terms of the importance of their contributions toward overall Navy laboratory success in providing innovative technology to meet system performance requirements.

Other Hypotheses—Individual Technology Area Performance

This study also sought to determine, in terms of individual technology areas, the success of Navy laboratories and private industry in supplying innovative technology to the respondent organizations. The specific working hypotheses follow.

Working (Null) Hypotheses 24. In terms of technology area, there is no difference in the reported frequency of success of Navy laboratories in providing innovative technology to meet new system performance requirements.

Working (Null) Hypothesis 25. In terms of technology area, there is no difference in the importance of the contribution to overall Navy laboratory success in providing innovative technology to meet new system performance requirements.

Working (Null) Hypothesis 26. In terms of technology area, there is no difference in the reported frequency of success of private industry in providing innovative technology to meet new system performance requirements.

Working (Null) Hypothesis 27. In terms of technology area, there is no difference in the importance of the contribution to overall private industry success in providing innovative technology to meet new system performance requirements.

RESEARCH DESIGN

Within the context of the Navy research and development community, this study sought to evaluate the technology transfer activities occurring between various groups of for-profit and not-for-profit technology providers and technology users. This evaluation was based upon assessments made by technology users of the various factors which comprise the technology transfer mechanism.

The explanatory variables in this design constitute the ten factors in the Technology Transfer Hypothesis believed to be related to technology transfer success. These factors included: documentation, distribution, project, credibility, channel, capacity, linker, willingness, reward, and organization. The design used separate variables to differentiate Navy laboratory and private industry factor performance.

Additional information gathered included the extent of the evaluators' immediate organization's interaction with each of seven technology source communities, and thirteen specific Navy research and development organizations. Open-ended questions were provided to allow the respondent to identify organizations not listed on the questionnaire. Data describing the frequency of the respondent's involvement in each of nineteen specific technology areas was also obtained.

The dependent variables in this design included the respondent's assessment of his immediate organization's success in acquiring and implementing new and innovative technology, and an assessment of both private industry and Navy laboratory successes in providing innovative technology to meet new system performance requirements.

Demographic information describing the respondents' qualifications to provide valid responses, including the number of years of professional experience and the number of years in his or her present position, was also obtained.

COLLECTION OF DATA

Data were collected by a mailed questionnaire (Appendix A) that was sent to individuals responsible for the design for specification of new Navy equipment and weapon systems. A cover letter explaining the purpose of this research and signed by the Director of Navy Laboratories (Appendix B) accompanied the questionnaire.

A copy of the results of this study were offered as an incentive for participation. A postcard was additionally enclosed in the mailing which, while retaining anonymity, allowed the respondent to indicate a return mailing address. The information collection process used to gather this data is described below.

Data Sources

The four organizations sampled comprise those Department of Defense organizations which heavily influence, or are directly responsible for the acquisition and implementation of new and innovative technology in Navy equipment and weapon systems. These organizations included: the Defense Advanced Research Projects Agency (DARPA), Naval Air Systems Command (NAVAIR), Naval Sea Systems Command (NAVSEA), and the Space and Naval Warfare Systems Command (SPAWAR).

The Defense Advanced Research Projects Agency was established in 1958 partly due to the pressures forced by the Soviet launching of the Sputnik satellites, recognizing the need for an organization which could take a long term view regarding the development of high-risk technology. The organization explores the innovative application of new technologies where the risk and payoff are both high, but where success may provide significant new military options or applications.

The Naval Air Systems Command is responsible for the material support needs of Naval aircraft and air-launched weapon systems, as well as associated electronic components. The Naval Sea Systems Command has development and acquisition responsibility for ships, submersibles, propulsion, shipboard combat systems, and explosive ordnance. The Space and Naval Warfare Systems Command provides systems which support command, control and communications, undersea and space surveillance, electronic warfare, and intelligence collection systems. These latter three organizations are collectively referred to in this study as the Naval Systems Commands.

Questionnaires sent to the Naval Systems Commands were addressed to individuals identified in the Department of Defense Telephone Directory as first or second line managers of technical groups, or individual technical specialists. Due to the relatively small number of total personnel within the Defense Advanced Research Projects Agency, questionnaires were sent to all scientists, engineers, and technical managers within that organization.

Instrumentation

Data were collected by a researcher-designed questionnaire. The information collected consisted of assessments of the environment, behavior, and performance of various organizations participating in the technology transfer process within the Navy research and development community.

The first section of the questionnaire, Section A, collected information used to identify the frequency of interaction of the respondent with various technology provider groups; Question 1 asked the respondent to indicate on a six-point scale his organizational code's or office's frequency of interaction with seven major technology provider communities. Additionally the respondent was provided an open-ended question to identify interaction with an unlisted community.

Question 2 provided information to identify the frequency of interaction of the respondent with each of the individual federal laboratories which comprise the Navy laboratory community. Respondents who indicated that they never sought 'innovative technology' were not required to proceed further in the questionnaire.

Question 3 was an open ended question which allowed the respondent to identify any unlisted Navy research and development activities with which they interacted when seeking innovative technology. Question 4 was an open ended question which asked the respondent to identify by firm name, key private industry sources of innovative technology.

Question 5, which comprised the entirety of Section B, provided for the measurement of the respondent's frequency of involvement in each of nineteen major technology areas. The technology categorization used in this study was derived from the Director of Navy Laboratory's (DNL) long term planning document, the *DNL Strategic Plan* (1988).

Section C consisted of questions which measured attributes associated with the ten explanatory variables of the Technology Transfer Hypotheses. All questions in Section C utilized a six-point measurement scale.

Question 6 measured the respondent's perceived importance of each of the ten explanatory variables which comprise the technology transfer mechanism.

Question 7 measured explanatory variables associated with the respondent's immediate organization and hypothesized to be related to technology transfer success. These variables included: capacity, linker, willingness, reward, and organization.

Question 8 measured factors associated with companies in private industry with which the respondent interacted when seeking new and innovative technology. These factors included: documentation,

distribution, project, credibility, and channel. Question 9 measured the identical factors for the Navy laboratories with which the respondent interacted when seeking new and innovative technology.

Question 10 provided demographic data, including years of professional experience and years in current position, which were used to validate the opinions expressed by the respondent.

Pretest For Clarification Of Questionnaire Content

The questionnaire was evaluated by ten senior personnel at the Naval Ocean Systems Center who were familiar with the intended respondent organizations and associated personnel capabilities. Based upon their comments and recommendations minor corrections and changes were made to further clarify questions and improve the visual appearance of the instrument.

The content validity of the revised instrument was established by a separate panel of five experts from various fields in the areas of science and technology. To establish content validity each question was judged concerning the intended meanings of the responses at the extremes of the scale for that item.

Research Procedure

The following procedure was followed in the design, validation and administration the test instrument:

1. Initial conception of the questionnaire design (21 October 1988);
2. Questionnaire was reviewed and critiqued by senior technical personnel at the Naval Ocean Systems Center, some minor revisions made;
3. Reviewed revised questionnaire with dissertation committee members and Dr. Frederick Korf (11 January 1989);
4. Established content validity through evaluation by panel of five expert judges;
5. Based upon validated questionnaire, sought and received endorsement of this study by the Director of Navy Laboratories (23 January 1989);
6. Drafted cover letter to be sent out with questionnaire and obtained Director of Navy Laboratories' signature (25 January 1989);
7. The most recent Defense Advanced Research Projects Agency Telephone Directory (dated January 1989) was used to generate a mailing list of all technical personnel;
8. The most recent Department of Defense Telephone Directory (dated August 1988) was used to generate a mailing list of all first and second line supervisors, and technical specialists in the Naval Air Systems Command (NAVAIR), Naval Sea Systems Command (NAVSEA), and Space and Naval Warfare Systems Command (SPAWAR);
9. Mailed cover letters, questionnaires, and return postcard request for study results to the above described personnel (30 January 1989);
10. Each returned questionnaire was reviewed for completeness (8 February - 20 March 1989).

Questionnaire Response

Table 1 shows the distribution of the responses from the four major respondent organizations. The category "Did Not Seek New Technology" shows respondents who indicated on the return questionnaire that they never sought new or innovative technology. All such questionnaires were removed from further analysis.

Table 1
Questionnaire Response Frequencies
by Organization in the Major
Response Categories

Response	DARPA	NAVAIR	NAVSEA	SPAWAR	Total
Did Not Respond	76	106	116	107	405
Did Not Seek New Technology	1	3	4	0	8
Usable Responses	32	77	142	91	342
Totals	109	186	262	198	755
% Usable Response	29	41	54	46	45

Legend:

DARPA - Defense Advanced Research Projects Agency

NAVAIR - Naval Air Systems Command

NAVSEA - Naval Sea Systems Command

SPAWAR - Space and Naval Warfare Systems Command

A Chi-Square test for response bias from the evaluating organizations was conducted. The results of that analysis indicated that at the $\alpha=.05$ level a significant response bias was present. Major contributors to this bias included the Defense Advanced Research Projects Agency, which had a response rate much lower than expected, and the Naval Sea Systems Command which had a response rate much higher than expected. The presence of this bias, however, did not adversely impact the analysis methodology used in this study.

Tests were additionally performed to assess the validity of the assumption that the sample responses accurately represented the opinions of the total study population. This non-response bias was evaluated by conducting t-tests to determine if significant differences existed between the means of corresponding evaluations of the last 25 questionnaires received versus all previous responses.

With one exception no significant differences in the corresponding evaluations were present. That exception was the respondent's self evaluation of success in acquiring and implementing new and innovative technology. For that question the last 25 received questionnaires indicated a significantly lower frequency of success than the composite of all previously received responses.

Description Of The Sample

The following tables provide descriptive information regarding the sample population. Table 2 lists information describing demographic variables of the respondents, including years of professional experience and time in present position. Additionally one-way analysis of variance (ANOVA) tests were performed to determine if significant differences existed among the means of the respondent organizations.

Table 2
Measured Mean and Standard Deviation by
Organization of Respondent's Years of
Professional Experience and Years
in Present Position

Demographic Variable	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Years Professional Experience					
Mean	21.3	20.1	23.7	21.6	4.51
Std. Dev.	5.6	7.9	7.2	7.1	.004
Years in Present Position					
Mean	3.2	4.6	4.9	4.0	1.49
Std. Dev.	2.6	4.2	5.1	4.5	.216

Legend:

DARPA - Defense Advanced Research Projects Agency
 NAVAIR - Naval Air Systems Command
 NAVSEA - Naval Sea Systems Command
 SPAWAR - Space and Naval Warfare Systems Command

Table 3 provides summary statistics regarding the extent of interaction of the respondent organizations with each of seven technology source communities. In addition, an open-ended question which was provided to allow the respondent to identify additional technology suppliers listed foreign government laboratories and universities as a primary additional source. One-way analysis of variance (ANOVA) tests were performed to determine if significant differences existed among the means of the respondent organizations.

Table 3
Mean Frequency of Interaction of
Respondent Organizations with
Technology Source Communities

Technology Source Community	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Navy Laboratories					
Mean	3.8	4.5	5.1	4.8	14.89
Std. Dev.	1.2	1.3	1.0	1.1	<.0005
Air Force Laboratories					
Mean	3.5	2.7	1.7	2.0	33.26
Std. Dev.	1.3	1.2	0.9	1.0	<.0005
Army Laboratories					
Mean	3.9	2.1	1.9	1.5	45.34
Std. Dev.	1.2	1.0	1.0	0.8	<.0005
Department of Energy Laboratories					
Mean	3.3	1.9	1.8	1.6	24.66
Std. Dev.	1.3	1.1	0.9	1.0	<.0005
NASA Laboratories					
Mean	2.7	2.3	1.7	1.5	13.63
Std. Dev.	1.3	1.4	0.9	1.0	<.0005
Universities and Affiliates					
Mean	3.8	2.5	3.3	3.0	11.07
Std. Dev.	1.3	1.3	1.2	1.3	<.0005

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 3 (continued)

Mean Frequency of Interaction of
Respondent Organizations with
Technology Source Communities

Technology Source Community	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Private Industry					
Mean	5.1	4.3	4.4	4.7	6.01
Std. Dev.	0.8	1.2	1.1	1.0	<.0005
Other Sources					
Mean	4.3	3.8	3.3	4.1	
Std. Dev.	2.0	1.9	1.7	1.1	

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 4 provides a description of the frequency of interaction of the respondent organizations with each of thirteen specific Navy technology source organizations. One-way analysis of variance (ANOVA) tests were conducted to determine if significant differences existed among the means of the respondent organizations.

Table 4

Mean Frequency of Interaction of
Respondent Organizations with
Navy Research and Development
Organizations

Navy R&D Organization	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
David Taylor Research Center					
Mean	2.3	2.3	3.9	2.1	42.36
Std. Dev.	1.1	1.3	1.6	1.2	<.0005

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 4 (continued)

**Mean Frequency of Interaction of Respondent Organizations with
Navy Research and Development Organizations**

Navy R&D Organization	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Naval Air Development Center					
Mean	2.7	4.2	2.5	2.8	30.02
Std. Dev.	1.2	1.3	1.3	1.4	<.0005
Naval Civil Engineering Laboratory					
Mean	1.5	1.4	1.6	1.6	2.00
Std. Dev.	0.8	0.7	0.9	1.1	.114
Naval Coastal Systems					
Mean	1.8	1.6	2.6	1.7	14.38
Std. Dev.	0.9	0.8	1.4	1.2	<.0005
Naval Ocean Systems Center					
Mean	3.2	2.6	3.5	4.5	29.91
Std. Dev.	1.3	1.2	1.3	1.4	<.0005
Naval Personnel Research and Development Center					
Mean	1.4	1.4	1.8	1.6	5.53
Std. Dev.	0.7	0.7	1.0	0.9	.001
Naval Research Laboratory					
Mean	3.5	3.4	3.4	4.0	3.31
Std. Dev.	1.3	1.3	1.3	1.4	.020
Naval Surface Warfare Center					
Mean	2.8	2.8	3.7	3.1	8.63
Std. Dev.	1.1	1.3	1.6	1.6	<.0005

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 4 (continued)

Mean Frequency of Interaction of Respondent Organizations with
Navy Research and Development Organizations

Navy R&D Organization	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Naval Training Systems Center					
Mean	1.7	2.1	2.1	1.7	3.57
Std. Dev.	0.8	1.1	1.2	1.0	.014
Naval Underwater Systems Center					
Mean	2.3	2.0	3.1	3.0	11.93
Std. Dev.	1.1	1.0	1.6	1.7	<.0005
Naval Weapons Center					
Mean	3.1	3.9	2.7	2.0	27.84
Std. Dev.	1.1	1.4	1.4	1.2	<.0005
Office of Naval Research					
Mean	2.4	2.7	2.7	2.5	3.47
Std. Dev.	1.3	1.4	1.2	1.4	.016
Office of Naval Technology					
Mean	3.3	2.6	2.7	2.4	3.51
Std. Dev.	1.2	1.6	1.2	1.4	.016

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

An open-ended question also allowed the respondent to identify Navy research and development organizations which additionally served as sources of new technology information. Generally not many responses were provided. The Naval Air Systems Command however was the most responsive and did indicate interaction with a number of the organization's field activities including: the Naval Air Propulsion Center, Pacific Missile Test Center, Naval Air Engineering Center, and Naval Avionics Center.

The respondents were also requested to identify key companies in private industry with which they interacted when seeking innovative technology. An extensive listing of industry firms was obtained. Table 5 provides the frequency of identification of individual companies by responding organization. As may be noted the most frequently listed companies included American Telephone and Telegraph (AT&T),

General Dynamics, General Electric, Hughes, International Business Machines (IBM), Lockheed, Martin-Marietta, Raytheon, Rockwell, Unisys, and Westinghouse.

Table 5
**Frequency of Identification of Key Private Industry
Technology Suppliers**

Private Industry Technology Supplier	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91
American Telephone and Telegraph (AT&T)	4	5	10	21
Boeing	-	14	3	2
General Dynamics	5	13	26	5
General Electric	2	9	43	21
Grumman	-	14	-	3
Honeywell	8	12	-	-
Hughes	10	12	25	25
International Business Machines (IBM)	3	9	12	8
Lockheed	11	13	3	13
Martin-Marietta	6	3	14	11
McDonnell-Douglas	7	16	-	4
Motorola	-	-	4	7
Newport News Shipbuilding	-	-	18	-
Northrop	2	6	-	-

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 5 (continued)
Frequency of Identification of Key Private Industry
Technology Suppliers

Private Industry Technology Supplier	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91
Radio Corporation of America (RCA)	-	-	4	2
Raytheon	5	5	26	12
Rockwell	8	6	16	15
Texas Instruments (TI)	4	6	3	-
Thomas Ramos Woolridge (TRW)	6	2	-	18
Unisys	-	-	18	12
Westinghouse	5	5	37	6

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 6 describes the extent of involvement of the respondent organizations in each of nineteen technology areas. One-way analysis of variance (ANOVA) tests were also performed to determine if significant differences existed among the means of the respondents' frequencies of involvement.

Table 6
Mean Frequency of Involvement of
Respondent Organizations by Technology Areas

Technology Area	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Stealth					
Mean	3.1	3.3	3.5	2.2	13.44
Std. Dev.	1.5	1.7	1.7	1.3	<.0005

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 6 (continued)
Mean Frequency of Involvement of Respondent Organizations
by Technology Area

Technology Area	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Directed Energy					
Mean	2.3	2.2	1.8	1.6	4.03
Std. Dev.	1.5	1.5	1.2	1.2	.008
Computing Power/ Modeling					
Mean	3.7	2.6	2.7	3.0	4.62
Std. Dev.	1.5	1.5	1.6	1.7	.003
Software Engineering					
Mean	3.8	3.4	3.3	4.1	4.76
Std. Dev.	1.7	1.6	1.6	1.5	.003
Fiberoptics and Photonics					
Mean	3.4	3.3	3.0	3.1	1.07
Std. Dev.	1.5	1.5	1.4	1.5	.360
Nonconventional Energy					
Mean	2.6	1.9	1.9	1.5	6.81
Std. Dev.	1.3	1.4	1.2	0.9	<.0005
Superconductivity					
Mean	2.6	2.3	2.0	1.5	8.68
Std. Dev.	1.4	1.6	1.2	0.9	<.0005
Autonomous Vehicles					
Mean	4.0	2.9	2.4	2.3	9.45
Std. Dev.	1.7	1.7	1.6	1.6	<.0005
Submarine Detection					
Mean	2.5	2.7	3.2	3.0	2.41
Std. Dev.	1.7	1.8	2.0	2.1	.067

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 6 (continued)
Mean Frequency of Involvement of Respondent Organizations
by Technology Area

Technology Area	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Cooperative Engagement Technology					
Mean	3.2	3.3	3.0	4.1	7.99
Std. Dev.	1.6	1.6	1.7	1.7	<.0005
Application of Engineered Materials					
Mean	2.7	3.1	3.2	2.0	13.22
Std. Dev.	1.6	1.7	1.6	1.3	<.0005
Information Management and Decision-Making					
Mean	3.6	3.1	3.2	3.7	3.16
Std. Dev.	1.5	1.5	1.5	1.6	.025
Environmental Sciences					
Mean	2.5	2.6	3.0	3.2	3.01
Std. Dev.	1.5	1.6	1.6	1.8	.030
Insensitive Highly Energetic Materials					
Mean	2.5	2.4	2.4	1.3	10.95
Std. Dev.	1.6	1.8	1.6	0.8	<.0005
Simulation Technology					
Mean	3.7	3.3	3.3	3.0	1.78
Std. Dev.	1.5	1.6	1.6	1.5	.151
Space-Based Systems					
Mean	3.2	2.1	1.7	3.5	38.73
Std. Dev.	1.4	1.3	1.0	1.8	<.0005
Multi-Static Systems					
Mean	2.8	3.0	2.9	2.9	.114
Std. Dev.	1.5	1.8	1.8	1.8	.952

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 6 (continued)

Mean Frequency of Involvement of Respondent Organizations
by Technology Area

Technology Area	DARPA N=32	NAVAIR N=77	NAVSEA N=142	SPAWAR N=91	F-Ratio (p<x)
Advanced Sensors					
Mean	3.7	3.6	3.3	2.7	5.17
Std. Dev.	1.6	1.6	1.8	1.7	.002
Range and Test Technologies					
Mean	3.3	3.2	3.2	2.8	1.11
Std. Dev.	1.4	1.6	1.7	1.6	.345

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

ANALYSIS OF DATA

This section describes the techniques used to analyze the information gathered during this study. All data were ratio or interval data except for the respondent organization classification. Relationships established by statistical analyses were tested for significance at the alpha-.05 level, although exact probabilities have been shown. Statistical tests, except the Chi-Square test for response bias, were performed with the SPSS/PC+ version 1.0 software package. The Chi-Square test for response bias was calculated manually.

The Technology Transfer hypothesis was tested by ten working hypotheses which evaluated the relationships between 10 explanatory variables, and each of three independent variables: technology user success in acquiring and implementing new and innovative technology, Navy laboratory success in providing innovative technology, and private industry success in providing innovative technology. Ordinary-least-squares multiple linear regression was used to estimate the various regression coefficients, beta values, and overall R-squared values for the models.

The Technology Dependence hypothesis was tested by one working hypothesis which evaluated the relationships between corresponding technology transfer model regression coefficients, when that model was applied to various disparate types of technology. An F-test as described by Zar (1974) was used to test whether the various multiple regressions estimated the same population regression function.

The Financial Dependence hypothesis was tested by four working hypotheses which evaluated relationships between explanatory and dependent variables associated with Navy laboratory versus private industry technology transition performance. Mean comparisons between Navy laboratory and private industry performance were made using two-tailed paired t-tests to determine if differences existed.

One-way analysis of variance (ANOVA) tests were used to determine whether mean differences existed among the respondent organizations for individual variables. Significance of individual mean differences was determined through post hoc Scheffe tests. While quite conservative, the Scheffe test represented a general procedure which applied to all possible comparisons of means.

The Technology User Differences hypothesis was tested by two working hypotheses which evaluated the relationships among various explanatory and dependent variables associated with technology user performance. One-way analysis of variance (ANOVA) tests were used to determine if individual variable mean differences existed among the respondent organizations. Significance of individual mean differences for each variable were then determined through post hoc Scheffe tests.

The Technology User Dependence hypothesis was tested by two working hypotheses which evaluated the relationships between two explanatory variables, Navy laboratory success in providing innovative technology and private industry success in providing innovative technology, and the dependent variable, technology user success in acquiring and implementing new technology. An ordinary-least-squares multiple linear regression was used to estimate the various coefficients, beta values, and overall R-squared values for these relationships.

Individual Navy laboratory performance, in terms of factors in the the technology transfer model which apply to technology suppliers, and success in providing innovative technology were determined through decomposition using an ordinary-least-squares multiple linear regression technique. The applicable model factors which were analyzed included documentation, distribution, project, credibility, and channel.

The decomposition technique utilized was based upon the assumptions of the existence of a performance measure for each Navy laboratory, and that the respondent's overall assessment of Navy laboratory performance represented a composite of individual laboratory performance ratings, each weighted by the respondent's frequency of interaction with that laboratory. The composite rating provided by the respondent thus represented the sum of all individual laboratory ratings each multiplied by the respondent's normalized frequency of interaction with that laboratory.

As an example, if $F1$, $F2$, and $F3$ are, respectively, the normalized frequencies of interaction of the respondent with laboratories LAB1, LAB2, and LAB3, each of which possess performance ratings RATE1, RATE2, and RATE3, then the composite performance assessment, COMP, made by the respondent may be represented by the equation:

$$COMP = (F1 * RATE1) + (F2 * RATE2) + (F3 * RATE3)$$

Since the composite performance rating, COMP, and frequency of interaction with each laboratory, $F1$, $F2$, and $F3$, are provided by each respondent, the individual performance ratings, RATE1, RATE2, and RATE3, may be estimated using ordinary-least-squares multiple regression.

The contribution of individual technology areas to the overall success of technology suppliers in providing innovative technology was also determined through decomposition using an ordinary-least-squares multiple linear regression technique.

The decomposition technique utilized was based upon the assumptions of the existence of a performance measure for each technology area, and that overall technology supplier success in providing innovative technology represented a composite of individual technology area ratings, each weighted by the respondent's frequency of involvement with that technology. The composite success rating provided by the respondent thus represented the sum of all individual technology area ratings each multiplied by the respondent's normalized frequency of involvement with that technology.

As an example, if F1, F2, and F3 are, respectively, the normalized frequencies of involvement of the respondent with technology areas TECH1, TECH2, and TECH3, each of which possess individual performance ratings RATE1, RATE2, and RATE3, then the composite performance assessment, COMP, made by the respondent may be represented by the equation:

$$COMP = (F1 * TECH1) + (F2 * TECH2) + (F3 * TECH3)$$

Since the composite performance rating, COMP, and frequency of involvement in each technology area, F1, F2, and F3, are provided by each respondent, the individual performance ratings, TECH1, TECH2, and TECH 3, may be estimated using ordinary-least-squares multiple linear regression.

RESEARCH ASSUMPTIONS AND DELIMITATIONS

There were specific assumptions that were central to the design of this research. The research also has specific limitations. These are discussed below.

Assumptions

This research was based upon the following assumptions:

1. This research was based upon the ability of the technology transfer model used in this study to accurately describe the technology transfer process within the Navy research and development community. The validity of this assumption was addressed by this study.
2. Information obtained for analysis in this study was based upon assessments made by technical personnel within various technology user organizations. It was assumed that the responses of the subjects were candid and truthful.
3. The analysis performed in this study was based upon assessments made by respondents which represented approximately 45 percent of the total study population. It was assumed that these respondents accurately reflected the views of the total population.
4. Determination of individual Navy laboratory performance was based upon the assumption that the overall performance assessment made by the respondent represented a combination of individual laboratory performance measures, weighted by the frequency of interaction of the respondent with the respective laboratories.
5. Determination of Navy laboratory and private industry success in each technology area is based upon the assumption that overall success in providing innovative technology represented a composite of individual technology area ratings, each weighted by the respondent's frequency of involvement with that technology.

Delimitations

This research was also limited by the following conditions:

1. Although they are members of the Systems Command community, the Naval Facilities Engineering Command and the Naval Supply Systems Command were not included in this study due to the relatively small size of their respective Research, Development, Test and Evaluation budgets.
2. The respondent was made aware by the return address on the questionnaire that the Naval Ocean Systems Center, one of the Navy research and development laboratories, was

conducting this study. That knowledge may have biased the respondents' assessments of Navy laboratory performance.

3. Other variables that may be related to technology transfer success but were not considered in this study include length of time in the respondent's present position, size of the technology user organizations, and size of the technology provider organizations.

SUMMARY

Within the context of the Navy research and development community, this study sought to evaluate the technology transfer activities occurring between various groups of for-profit and not-for-profit technology providers and technology users. This evaluation was based upon assessments made by technology users of the various factors which comprise the technology transfer mechanism.

The explanatory variables in this design constitute the ten factors in the Technology Transfer Hypotheses believed to be related to technology transfer success. These factors included: documentation, distribution, project, credibility, channel, capacity, linker, willingness, reward, and organization. The design used separate variables to differentiate Navy laboratory and private industry factor performance.

A researcher-designed questionnaire was developed to measure various dependent and explanatory variables. The questionnaire was sent to key technical personnel in Department of Defense organizations which were responsible for, or heavily influenced, the acquisition and implementation of new and innovative technology in Navy equipments and weapon systems. The questionnaires were mailed with a cover letter signed by the Director of Navy Laboratories and a postcard to indicate a return address for a copy of the study results.

All data generated were ratio or interval data, except for the nominal organization classification. The significance of relationships was tested at the $\alpha=.05$ level.

The data analysis procedures included ordinary-least-squares multiple linear regression for analysis of the technology transfer model, t-Tests to test for mean differences, and one-way analysis of variance (ANOVA) with post hoc Scheffe procedures to test for and identify individual mean differences. An analysis technique described by Zar (1974) was used to determine if various multiple regressions estimated the same population regression function.

Assumptions made in this study were centered around the ability of the technology transfer model used in this study to accurately describe the technology transfer process within the Navy research and development community. The validity of this assumption was addressed by this study.

CHAPTER 4

FINDINGS

This chapter describes the results of the data analyses that were presented in Chapter 3, Method. Three primary research hypotheses were evaluated. The Technology Transfer Hypothesis described the relationships between ten personal and organization characteristics and: (1) technology supplier success in providing innovative technology, and (2) technology user success in acquiring and implementing new and innovative technology. The Technology Dependence Hypothesis described the relationship between the ten factors in the technology transfer model and the type of technology involved. And the Financial Dependence Hypothesis described the relationship between the technology transfer performances of for-profit versus not-for-profit technology provider organizations.

Other hypotheses described additional relationships that were examined to provide a more complete understanding of the technology transfer process. The Technology User Differences Hypothesis examined possible differences among the evaluating organizations in terms of the various factors in the technology transfer model. The Technology User Dependence Hypothesis described the relationship between technology supplier success in providing innovative technology and respondent success in acquiring and implementing new technology.

The Individual Navy Laboratory Performance Hypothesis described the relative performances of the Navy laboratories in terms of various characteristics which affect technology transfer performance, and success in providing new and innovative technology. The Individual Technology Area Performance Hypothesis described, for individual technology areas, Navy laboratory and private industry success in supplying innovative technology.

TESTS OF HYPOTHESES

Hypothesis were tested through the use of ordinary-least-squares multiple linear regression to determine relationships between explanatory and dependent variables. Paired t-Tests were used to determine if differences existed between pairs of means. For comparisons of three or more means, one-way analysis of variance (ANOVA) was used to determine if the samples belonged to the same population. The post hoc Scheffe test was used to identify individual mean differences. Ordinary-least-squares multiple linear regression was also used to decompose overall performance measures into various contributing components. The results of the hypotheses tests are shown below.

Technology Transfer Hypothesis

Ordinary-least-squares multiple linear regressions were performed to determine the ability of the ten factors in the technology transfer model to explain: (1) the frequency of Navy laboratory success in providing innovative technology to meet system performance design requirements; (2) the frequency of private industry success in providing innovative technology to meet system performance design requirements; and (3) the frequency of technology user success in acquiring and implementing new and innovative technology.

The respondent technology user organizations indicated that the presence of the following model factors possessed a significant positive relationship to the successful transfer of innovative technology from Navy laboratories: Documentation, Project, Credibility, Channel, and Organization. The technology transfer model was able to account for 59 percent of the variation in technology transfer success. These results are shown in Table 7.

Table 7
Results of Multiple Regression Analysis of Respondents Reporting
Frequency of Success of Navy Laboratories in Providing
Innovative Technology

Variable	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Documentation	.115 (.054)	.113	2.14	.033*
Distribution	.044 (.047)	.049	.94	.384
Project	.284 (.045)	.314	6.34	<.0005**
Credibility	.306 (.049)	.311	6.29	<.0005**
Channel	.134 (.044)	.150	3.04	.003**
Capacity	-.066 (.052)	-.072	-1.26	.209
Linker	-.075 (.059)	-.086	-1.26	.210
Willingness	.021 (.056)	.023	.37	.712
Reward	.024 (.034)	.030	.72	.474
Organization	.077 (.037)	.097	2.08	.039*
(Constant)	.198 (.220)	—	.90	.368
R-squared	.589			

*p<.05

**p<.01

With respect to the transfer of innovative technology from private industry, the technology user organizations indicated that the presence of the following model factors exhibited a significant positive relationship to success: Documentation, Project, Credibility, and Channel. The model was able to account for 50 percent of the variation in technology transfer success relating to private industry. These results are shown in Table 8.

Table 8
Results of Multiple Regression Analysis of Respondents Regarding
Frequency of Success of Private Industry in Providing
Innovative Technology

Variable	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Documentation	.166 (.055)	.175	3.04	.002**
Distribution	-.025 (.050)	-.028	-.50	.615
Project	.137 (.047)	.151	2.92	.004**
Credibility	.338 (.050)	.321	6.74	<.0005**
Channel	.219 (.042)	.251	5.25	.0005**
Capacity	-.012 (.055)	-.014	-.21	.830
Linker	-.002 (.060)	-.002	-.03	.978
Willingness	.071 (.058)	.087	1.21	.226
Reward	-.051 (.034)	-.070	-1.49	.137
Organization	.064 (.037)	.088	1.71	.088
(Constant)	.256 (.233)	—	.1.10	.273
R-squared	.499			

*p<.05

**p<.01

The respondent organizations indicated that the presence of the following factors possessed a significant positive relationship to their successful acquisition and implementation of innovative technology: Documentation, Credibility, Capacity, Reward, and Organization. The presence of the following model factors was found to have a significant negative relationship to technology transfer success: Distribution and Channel. In this case the model was able to account for 50 percent of the variation in technology transfer success. These results are shown in Table 9.

Table 9
Results of Multiple Regression Analysis of Respondents Regarding
Frequency of Success in Acquiring and Implementing
Innovative Technology

Variable	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Documentation	.202 (.086)	.145	2.37	.019*
Distribution	-.162 (.077)	-.125	-2.12	.035*
Project	.102 (.081)	.074	1.33	.185
Credibility	.167 (.065)	.112	2.07	.039*
Channel	-.147 (.065)	-.119	-2.24	.026*
Capacity	.215 (.074)	.201	2.90	.004**
Linker	-.118 (.078)	-.120	-1.50	.133
Willingness	.198 (.073)	.196	2.70	.007**
Reward	.161 (.044)	.177	3.68	<.0005**
Organization	.321 (.047)	.357	6.81	<.0005**
(Constant)	.035 (.321)	—	.108	.914
R-squared	.496			

*p<.05

**p<.01

Technology Dependence Hypothesis

Ordinary-least-squares multiple linear regressions were performed on each of seven subsets of the data which represented a broad spectrum of diverse technology categorizations. These categorizations provided a segmentation of respondent technology involvement based upon various technology attributes, including for example product versus process technology.

The technology groupings used included:

1. Computer Technology—including computing power/modeling, software engineering, cooperative engagement technologies, information management and decision-making, and simulation technology.
2. Software Technology—including software engineering and information management and decision-making.
3. Command, Control, and Communications Technology—including cooperative engagement technologies and space-based systems.
4. Fiberoptics and Photonics Technology—including fiber transmission lines, optical sources, sensors and components.
5. Advanced Sensor Technology—including transducers and electromagnetic devices, and navigation sensors.
6. Space-based System Technology—including communications, surveillance, and data processing.
7. Autonomous Vehicle Technology—including guidance and control, automatic targeting, intelligent subsystems, and telecommunications.

The results of this analysis, as well as the regression for the entire data set, are shown in table 10. An analysis technique described by Zar (1974) was used to determine if the various multiple regressions estimated the same population regression function. The results of this analysis indicated that the regressions did come from the same population. The results are shown in table 11.

Financial Dependence Hypothesis

Paired t-Tests were conducted to ascertain at the $\alpha=.05$ level whether or not to accept or reject the working hypotheses of no difference between means of Navy laboratory versus private industry performance for each of the following factors in the technology transfer model: Documentation, Distribution, Project, Credibility, and Channel.

None of the technology user organizations saw a significant difference between Navy laboratories and private industry in the frequency of the Documentation factor. These results are shown in Table 12.

Each of the three Naval Systems Commands saw a significantly higher frequency of the Distribution factor from Navy laboratories. The Defense Advanced Research Projects Agency saw no significant difference. These results are shown in Table 13.

The Defense Advanced Research Projects Agency and the Space and Naval Warfare Systems Command both saw a significantly higher frequency of Project and Credibility factors in private industry than in the Navy laboratories. These results are shown in Tables 14 and 15.

Table 10
Results of Multiple Regression Analysis of Success in
Acquiring and Implementing New Technology by Technology Type

Factor	COMPOSITE Coefficient (SE)	CT Coefficient (SE)	ST Coefficient (SE)	CCC Coefficient (SE)
Documentation	.202 (.086)	.108 (.128)	.005 (.138)	.125 (.167)
Distribution	-.162 (.077)	-.082 (.118)	-.065 (.128)	.113 (.150)
Project	.102 (.077)	.156 (.116)	.308 (.146)	.044 (.165)
Credibility	.167 (.081)	.162 (.126)	.026 (.143)	.122 (.168)
Channel	-.147 (.065)	-.262 (.096)	-.170 (.108)	-.256 (.135)
Capacity	.215 (.074)	.216 (.105)	.209 (.129)	.147 (.141)
Linker	-.118 (.078)	-.165 (.113)	-.146 (.128)	-.166 (.160)
Willingness	.198 (.073)	.253 (.103)	.250 (.114)	.312 (.144)
Reward	.161 (.044)	.244 (.067)	.213 (.078)	.260 (.086)
Organization	.321 (.047)	.255 (.074)	.217 (.084)	.246 (.095)
(Constant)	.035 (.321)	.248 (.546)	.510 (.600)	.124 (.724)
R-squared	.496	.450	.480	.431

Legend:

CT - Computer Technology

ST - Software Technology

CCC - Command, Control, and Communications Technology

Table 10 (continued)

Results of Multiple Regression Analysis of Success in
Acquiring and Implementing New Technology by Technology Type

Factor	FPT Coefficient (SE)	AST Coefficient (SE)	SST Coefficient (SE)	AVT Coefficient (SE)
Documentation	.236 (.230)	-.056 (.161)	-.259 (.374)	-.055 (.242)
Distribution	.006 (.229)	.120 (.151)	.285 (.290)	.489 (.221)
Project	-.085 (.281)	.028 (.140)	-.461 (.337)	.137 (.193)
Credibility	-.037 (.227)	.184 (.160)	.490 (.340)	.420 (.280)
Channel	-.081 (.215)	-.146 (.126)	-.056 (.343)	-.476 (.233)
Capacity	-.151 (.274)	.122 (.131)	.192 (.258)	.101 (.217)
Linker	-.014 (.264)	.035 (.154)	.069 (.276)	0.55 (.258)
Willingness	.496 (.265)	.076 (.127)	.270 (.261)	.170 (.248)
Reward	.257 (.171)	.173 (.082)	.093 (.224)	.143 (.123)
Organization	.197 (.150)	.365 (.092)	.347 (.236)	.216 (.147)
(Constant)	.906 (1.264)	.269 (.688)	-.300 (1.780)	-1.220 (.955)
R-squared	.444	.474	.528	.652

Legend:

FPT - Fiberoptics and Photonics Technology

AST - Advanced Sensor Technology

SST - Space-Based Systems Technology

AVT - Autonomous Vehicle Technology

Table 11
Results of F-Test for Determination
of Technology Type Relationship

Source	df	rss	F-Ratio	Prob. (p<x)
Technology:				
CT	129	93.54		
ST	95	65.08		
CCC	84	69.40		
FPT	39	35.88		
AST	74	45.68		
SST	20	17.37		
AVT	<u>36</u>	<u>21.34</u>		
Pooled	477	348.29	.45	N.S.
Composite	543	370.00	df=66, 477	

Legend:

CT - Computer Technology
ST - Software Technology
CCC - Command, Control, and Communications Technology
FPT - Fiberoptics and Photonics Technology
AST - Advanced Sensor Technology
SST - Space-Based Systems Technology
AVT - Autonomous Vehicle Technology

Table 12

Results of Paired t-Tests for Mean Differences in the
Frequency of the Documentation Factor

Evaluating Organization	Mean	<u>SD</u>	t	df	Two-tail Prob. (p<x)
DARPA					
Navy Laboratories	3.69	.85	-.87	28	.394
Private Industry	3.86	.83			
NAVAIR					
Navy Laboratories	3.44	.87	-.24	72	.810
Private Industry	3.47	.99			
NAVSEA					
Navy Laboratories	3.66	1.00	.96	141	.338
Private Industry	3.58	.90			
SPAWAR					
Navy Laboratories	3.25	.94	-1.97	84	.052
Private Industry	3.52	1.05			

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 13
Results of Paired t-Tests for Mean Differences in the
Frequency of the Distribution Factor

Evaluating Organization	Mean	SD	t	df	Two-tail Prob. (p<x)
DARPA					
Navy Laboratories	3.97	.87	.72	28	.475
Private Industry	3.83	.76			
NAVAIR					
Navy Laboratories	3.79	1.07	2.99	71	.004**
Private Industry	3.33	1.03			
NAVSEA					
Navy Laboratories	4.22	1.02	7.36	141	<.0005**
Private Industry	3.51	.92			
SPAWAR					
Navy Laboratories	3.88	1.13	2.15	83	.034*
Private Industry	3.54	1.20			

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 14
Results of Paired t-Tests for Mean Differences in the
Frequency of the Project Factor

Evaluating Organization	Mean	SD	t	df	Two-tail Prob. (p<x)
DARPA					
Navy Laboratories	3.38	.82	-5.39	28	<.0005**
Private Industry	4.59	.68			
NAVAIR					
Navy Laboratories	3.72	1.08	1.16	70	.252
Private Industry	3.59	1.06			
NAVSEA					
Navy Laboratories	3.89	1.09	-.21	141	.836
Private Industry	3.92	1.00			
SPAWAR					
Navy Laboratories	3.54	1.11	-2.10	83	.039*
Private Industry	3.89	.98			

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 15
Results of Paired t-Tests for Mean Differences in the
Frequency of the Credibility Factor

Evaluating Organization	Mean	SD	t	df	Two-tail Prob. (p<x)
DARPA					
Navy Laboratories	4.17	.97	-2.32	28	.028*
Private Industry	4.66	.72			
NAVAIR					
Navy Laboratories	4.18	1.01	-.75	72	.457
Private Industry	4.26	.87			
NAVSEA					
Navy Laboratories	4.52	.91	1.52	141	.130
Private Industry	4.39	.86			
SPAWAR					
Navy Laboratories	4.20	1.06	-2.89	84	.005**
Private Industry	4.60	.85			

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

The Naval Sea Systems Command was the only organization to see a significant difference in the frequency of the Channel factor, which was significantly higher for Navy laboratories. These results are shown in Table 16.

Table 16
Results of Paired t-Tests for Mean Differences in the
Frequency of the Channel Factor

Evaluating Organization	Mean	SD	t	df	Two-tail Prob. (p<x)
DARPA					
Navy Laboratories	3.41	1.02	-.12	28	.905
Private Industry	3.45	1.09			
NAVAIR					
Navy Laboratories	3.35	1.05	.84	73	.403
Private Industry	3.25	1.02			
NAVSEA					
Navy Laboratories	3.73	1.10	2.68	141	.008**
Private Industry	3.46	1.05			
SPAWAR					
Navy Laboratories	3.17	1.05	-.75	83	.457
Private Industry	3.26	1.02			

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

One-way analysis of variance (ANOVA) tests were conducted to ascertain at the alpha=.05 level whether or not there were significant differences between the means of the four technology user organizations in their assessments of Navy laboratories for each of the following Predictive Model of Technology Transfer factors: Documentation, Distribution, Project, Credibility, and Channel.

Significant F Ratios were found to exist for each of the five model-factors. However, the post hoc Scheffe procedure was able to identify individual differences in the means for only two of the factors, Documentation and Channel. These results are shown in Tables 17 through 21.

Table 17

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Navy Laboratory
Documentation Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	9.37	3.12	3.51	.015*
Within Groups	<u>328</u>	<u>291.62</u>	.89		
Total	331	300.99			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	29	73	143	87
Mean:	3.69	3.44	3.65	3.26
SD:	.85	.87	1.00	.93

The Scheffe tests revealed at the .05 level that:

1. NAVSEA indicated the presence of a significantly higher frequency of Documentation factor than SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 18

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Navy Laboratory
Distribution Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	10.82	3.61	3.22	.023*
Within Groups	<u>327</u>	<u>366.16</u>	1.12		
Total	330	376.97			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	29	72	143	87
Mean:	3.97	3.79	4.21	3.87
SD:	.87	1.07	1.03	1.14

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 19

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Navy Laboratory
Project Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	10.25	3.42	2.97	.032*
Within Groups	<u>328</u>	<u>376.70</u>	1.15		
Total	331	386.95			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	29	73	143	87
Mean:	3.38	3.74	3.89	3.54
SD:	.82	1.08	1.09	1.11

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 20

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Navy Laboratory
Credibility Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	8.38	2.79	2.95	.033*
Within Groups	<u>328</u>	<u>310.83</u>	.95		
Total	331	319.21			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	29	73	143	87
Mean:	4.17	4.18	4.51	4.21
SD:	.97	1.00	.91	1.05

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 21

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Navy Laboratory
Channel Factor

Source	df	ss	ms	F-Ratio	Prob. (p<α)
Between Groups	3	18.20	6.07	5.32	.001**
Within Groups	<u>328</u>	<u>374.43</u>	1.14		
Total	331	392.64			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	29	74	143	86
Mean:	3.41	3.35	3.72	3.16
SD:	1.02	1.05	1.10	1.03

The Scheffe tests revealed at the .05 level that:

1. NAVSEA indicated the presence of a significantly higher frequency of Channel factor than SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

One-way analysis of variance (ANOVA) tests were also conducted to ascertain at the alpha=.05 level whether or not there were significant differences between the means of the four technology user organizations in their assessments of private industry for each of the following Predictive Model of Technology Transfer factors: Documentation, Distribution, Project, Credibility, and Channel.

Significant F Ratios were found only for the Project and Credibility factors. The post hoc Scheffe procedure was able to identify individual differences in the means for only the Project factor. These results are shown in Tables 22 through 26.

Table 22

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Private Industry
Documentation Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	3.41	1.14	1.24	.296
Within Groups	<u>335</u>	<u>307.98</u>	.92		
Total	338	311.39			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	76	143	28
Mean:	3.84	3.46	3.57	3.53
SD:	.81	.97	.90	1.08

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 23

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Private Industry
Distribution Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	7.20	2.40	2.32	.075
Within Groups	<u>334</u>	<u>345.30</u>	1.03		
Total	331	392.64			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	76	143	87
Mean:	3.81	3.28	3.52	3.55
SD:	.74	1.04	.92	1.22

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 24

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Private Industry
Project Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	27.08	7.69	7.92	<.0005**
Within Groups	<u>331</u>	<u>321.38</u>	.97		
Total	334	344.46			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	73	143	87
Mean:	4.56	3.55	3.91	3.87
SD:	.67	1.08	1.00	.97

The Scheffe tests revealed at the .05 level that:

1. DARPA indicated the presence of a significantly higher frequency of Project factor than either NAVAIR, NAVSEA or SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 25

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Private Industry
Credibility Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	6.48	2.16	3.01	.031*
Within Groups	<u>334</u>	<u>239.87</u>	.72		
Total	337	346.34			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	76	143	87
Mean:	4.59	4.22	4.38	4.59
SD:	.71	.87	.86	.86

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 26

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for the Private Industry
Channel Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	3.43	1.15	1.07	.361
Within Groups	<u>335</u>	<u>357.98</u>	1.07		
Total	338	361.42			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	77	143	87
Mean:	3.41	3.24	3.46	3.26
SD:	1.04	1.01	1.05	1.03

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

- 1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Paired t-Tests were also conducted to ascertain at the $\alpha=.05$ level whether or not to accept or reject the working hypothesis of no difference between means of the frequency of Navy laboratory success versus private industry success in providing innovative technology to meet new system performance requirements.

Both the Defense Advanced Research Projects Agency and Space and Naval Warfare Systems Command viewed private industry as significantly more often successful than Navy laboratories in providing innovative technology. The Naval Air Systems Command and Naval Sea Systems Command saw no significant differences. These results are shown in Table 27.

Table 27

Results by Evaluating Organization of Paired t-Tests
for Differences in the Frequency of Success in Supplying
Innovative Technology

Evaluating Organization	Mean	SD	t	df	Two-tail Prob. (p<α)
DARPA					
Navy Laboratories	3.19	.69	-4.31	25	<.0005**
Private Industry	4.12	.77			
NAVAIR					
Navy Laboratories	3.40	.97	-1.93	71	.058
Private Industry	3.61	.83			
NAVSEA					
Navy Laboratories	3.72	1.04	-.77	140	.444
Private Industry	3.80	.92			
SPAWAR					
Navy Laboratories	3.47	.91	-4.79	84	<.0005**
Private Industry	4.13	.87			

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

A one-way analysis of variance (ANOVA) test was conducted to ascertain at the .05 level whether or not there were significant differences between the means of the four technology user organizations in their assessments of Navy laboratory success in providing innovative technology.

Although a significant F ratio was obtained indicating that differences did exist, the post hoc Scheffe procedure was unable to identify the individual differences. These results are shown in Table 28.

Table 28

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Navy Laboratory Success
in Providing Innovative Technology

Source	df	ss	ms	F-Ratio	Prob. (p<α)
Between Groups	3	9.46	3.15	3.40	.018*
Within Groups	<u>326</u>	<u>302.60</u>	.93		
Total	329	312.06			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	27	73	143	87
Mean:	3.19	3.41	3.71	3.46
SD:	.68	.97	1.04	.90

The Scheffe tests revealed at the .05 level that:

1. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

A one-way analysis of variance (ANOVA) test was also conducted to ascertain at the .05 level whether or not there were significant differences between the means of the four technology user organizations in their assessments of private industry success in providing innovative technology.

A significant F Ratio was found and the post hoc Scheffe procedure was able to identify evaluating organizations with significantly different assessments. The results are shown in Table 29.

Table 29

**Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Private Industry Success
in Providing Innovative Technology**

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	14.38	4.79	6.28	<.0005**
Within Groups	<u>332</u>	<u>253.32</u>	.76		
Total	335	267.70			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	31	76	142	87
Mean:	4.10	3.58	3.80	4.13
SD:	.75	.84	.92	.87

The Scheffe tests revealed at the .05 level that:

1. SPAWAR indicated the presence of a significantly higher frequency of success than NAVAIR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Other Hypotheses—Technology User Differences

One-way analysis of variance (ANOVA) tests were conducted to ascertain at the alpha=.05 level whether or not there were significant differences between the means of the four technology user organizations in their evaluations for each of the following factors in the technology transfer model: Organization, Capacity, Linker, Reward, and Willingness.

Significant F Ratios were found for each of the five model factors. The post hoc Scheffe procedure was able to identify individual mean differences in each case. These results are shown in Tables 30 through 34.

Table 30

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Organization Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	46.67	15.56	15.50	<.0005**
Within Groups	<u>340</u>	<u>341.31</u>	1.00		
Total	343	387.97			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	77	144	91
Mean:	5.41	4.10	4.17	4.13
SD:	.91	1.08	1.00	.97

The Scheffe tests revealed at the .05 level that:

1. DARPA indicated the presence of a significantly higher frequency of Organization factor than either NAVAIR, NAVSEA, or SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 31

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Capacity Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	62.19	20.73	18.82	<.0005**
Within Groups	341	375.61	1.10		
Total	344	437.80			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	78	144	91
Mean:	5.50	3.91	4.14	4.09
SD:	.67	1.21	1.05	1.01

The Scheffe tests revealed at the .05 level that:

1. DARPA indicated the presence of a significantly higher frequency of Capacity factor than either NAVAIR, NAVSEA, or SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 32

**Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Linker Factor**

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	57.14	19.05	17.88	<.0005**
Within Groups	<u>340</u>	<u>312.25</u>	1.07		
Total	343	419.40			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	78	144	90
Mean:	5.44	3.87	4.20	4.17
SD:	.62	1.11	1.03	1.07

The Scheffe tests revealed at the .05 level that:

1. DARPA indicated the presence of a significantly higher frequency of Linker factor than either NAVAIR, NAVSEA, or SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 33

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Reward Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	18.29	6.13	4.23	.006**
Within Groups	<u>326</u>	<u>302.60</u>	.93		
Total	329	312.06			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	26	74	139	87
Mean:	3.81	2.99	3.48	3.25
SD:	1.41	1.07	1.13	1.35

The Scheffe tests revealed at the .05 level that:

1. Both DARPA and NAVSEA indicated the presence of a significantly higher frequency of Reward factor than NAVAIR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Table 34

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Willingness Factor

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	45.86	15.29	10.74	<.0005**
Within Groups	340	483.95	1.42		
Total	343	529.81			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	78	144	90
Mean:	5.34	3.97	4.59	4.42
SD:	.83	1.35	1.10	1.30

The Scheffe tests revealed at the .05 level that:

1. DARPA indicated the presence of a significantly higher frequency of Willingness factor than either NAVAIR, NAVSEA, or SPAWAR.
2. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

A one-way analysis of variance (ANOVA) test was also conducted to ascertain at the alpha=.05 level whether or not there were significant differences between the means of the four technology user organizations in their evaluations of the frequency of success in acquiring and implementing innovative technology.

A significant F Ratio was found and the post hoc Scheffe procedure was able to identify individual organizations with significantly different assessments. These results are shown in Table 35.

Table 35

Results of ANOVA for Differences Between Means
of the Evaluating Organizations for Success in Acquiring
and Implementing New and Innovative Technology

Source	df	ss	ms	F-Ratio	Prob. (p<x)
Between Groups	3	43.91	14.64	12.99	<.0005**
Within Groups	338	380.95	1.13		
Total	341	424.86			

Table of Means

	DARPA	NAVAIR	NAVSEA	SPAWAR
N:	32	77	144	89
Mean:	4.94	3.55	3.99	3.99
SD:	.95	.99	1.06	1.15

The Scheffe tests revealed at the .05 level that:

1. DARPA indicated the presence of a significantly higher frequency of success in acquiring and implementing new technology than either NAVAIR, NAVSEA, or SPAWAR.
2. NAVSEA indicated the presence of a significantly higher frequency of success than NAVAIR.
3. No other two groups were significantly different.

*p<.05

**p<.01

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Legend:

DARPA - Defense Advanced Research Projects Agency
NAVAIR - Naval Air Systems Command
NAVSEA - Naval Sea Systems Command
SPAWAR - Space and Naval Warfare Systems Command

Other Hypotheses—Technology User Dependence

Ordinary-least-squares multiple linear regressions were performed to determine the relationships between Navy laboratory and private industry successes in providing innovative technology and technology user success in acquiring and implementing new and innovative technology.

Neither Navy laboratory success nor private industry success in providing innovative technology were significant in explaining variations in the success of the Defense Advanced Research Projects Agency in acquiring and implementing new and innovative technology. These results are shown in Table 36.

Table 36

Multiple Regression Analysis of the Contribution of Technology
Provider Success to the Success of DARPA in Acquiring and
Implementing New and Innovative Technology

Source	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Navy Laboratory Success	-.129 (.273)	-.093	-.47	.640
Private Industry Success	.427 (.247)	.338	1.73	.098
(Constant)	3.502 (1.428)	—	2.45	.022*
R-squared	.130			

*p<.05

**p<.01

Legend:

DARPA - Defense Advanced Research Projects Agency

Both Navy laboratory success and private industry success were found to be positively related to variations in the successes of both the Naval Air Systems Command and the Naval Sea Systems Command. Navy laboratory and private industry success accounted for 38 percent of the variation in the success of the Naval Air Systems Command, and 26 percent for the Naval Sea Systems Command. These results are shown in Tables 37 and 38.

Table 37

Multiple Regression Analysis of the Contribution of Technology
Provider Success to the Success of NAVAIR in Acquiring and
Implementing New and Innovative Technology

Source	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Navy Laboratory Success	.466 (.111)	.452	4.14	<.0005**
Private Industry Success	.309 (.131)	.256	2.36	.021*
(Constant)	.884 (.448)	—	1.97	.052
R-squared	.383			

*p<.05

**p<.01

Legend:

NAVAIR - Naval Air Systems Command

Table 38

**Multiple Regression Analysis of the Contribution of Technology
Provider Success to the Success of NAVSEA in Acquiring and
Implementing New and Innovative Technology**

Source	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Navy Laboratory Success	.313 (.077)	.307	4.06	<.0005**
Private Industry Success	.384 (.087)	.335	4.42	<.0005**
(Constant)	1.395 (.389)	—	3.49	.001**
R-squared	.256			

*p<.05

**p<.01

Legend:

NAVSEA - Naval Sea Systems Command

For the Space and Naval Warfare Systems Command, only private industry success was a significant positive factor in explaining the variation in that organization's success in acquiring and implementing new technology. Navy laboratory and private industry success in supplying innovative technology accounted for 10 percent of the variation in user success. These results are shown in Table 39.

Table 39

**Multiple Regression Analysis of the Contribution of Technology
Provider Success to the Success of SPAWAR in Acquiring and
Implementing New and Innovative Technology**

Source	Coefficient (Std Error)	Beta	t	Prob. (p<x)
Navy Laboratory Success	-.076 (.131)	-.061	-.58	.564
Private Industry Success	.411 (.138)	.315	2.97	.004**
(Constant)	2.587 (.742)	—	3.44	.001**
R-squared	.104			

*p<.05

**p<.01

Legend:

SPAWAR - Space and Naval Warfare Systems Command

Other Hypotheses—Individual Navy Laboratory Performance

Ordinary-least-squares multiple linear regressions were performed to determine the performances of the individual Navy laboratories for each of the following factors in the technology transfer model: Documentation, Distribution, Project, Credibility, and Channel, as well as overall success in providing new and innovative technology.

The coefficient values shown in Tables 40 to 45 provide a qualitative measure of performance for each laboratory irrespective of the size or level of effort of that laboratory. Additionally, since a statistical technique was used for this analysis, the 95 percent confidence interval for the coefficient value was provided.

In some cases the 95 percent confidence interval of these coefficients contained scale values outside the possible range of 1 to 6. While such values do not possess a real-world interpretation, they do accurately reflect the statistical nature of the decomposition method employed.

The Beta values shown represent the importance or magnitude of the individual laboratories' contribution toward overall Navy laboratory performance for each of the factors in the technology transfer model, as well as success in providing innovative technology. As such these values reflect a combination of both the quality of performance and the magnitude of the individual laboratories' efforts.

For each factor, and for overall success, R-squared values in excess of .92 were obtained.

Other Hypotheses—Individual Technology Area Performance

Multiple linear regressions were also performed to determine, in terms of individual technology areas, the success of Navy laboratories and private industry in supplying innovative technology to the respondent organizations.

The coefficients shown in Table 46 provide a measure, by technology area, of Navy laboratory success in providing new scientific knowledge to the respondent organizations. Likewise Table 47 provides the coefficients for private industry.

These coefficient values represent a qualitative measure of technology supplier performance for each technology area irrespective of the level of effort being pursued in that area. Additionally, since a statistical technique was used for this analysis, the 95 percent confidence interval for the coefficient value was additionally provided.

In some cases the 95 percent confidence interval for these coefficients contained scale values outside the possible range of 1 to 6. While such values do not possess a real-world interpretation, they do accurately reflect the statistical nature of the decomposition method employed.

The Beta values shown represent the importance or extent of contribution of individual technology areas toward overall Navy laboratory or private industry success in providing new scientific knowledge. Accordingly these values reflect both performance quality and the extent or level of effort within the individual technology areas.

R-square values in excess of .93 were obtained for the analysis of both Navy laboratory and private industry success.

Table 40

Multiple Regression Analysis for Determination of Individual Laboratory
Contribution to Documentation Factor

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
David Taylor Research Center	3.10	2.10	4.10	.118
Naval Air Development Center	3.15	2.03	4.28	.117
Naval Civil Engineering Laboratory	2.56	.12	4.99	.035
Naval Coastal Systems Center	5.00	2.87	7.13	.091
Naval Ocean Systems Center	1.83	.61	3.05	.080
Naval Personnel Research and Development Center	5.04	1.79	8.30	.058
Naval Research Laboratory	4.28	2.99	5.57	.186
Naval Surface Warfare Center	3.26	2.26	4.25	.133
Naval Training Systems Center	3.53	1.24	5.82	.061
Naval Underwater Systems Center	3.57	2.02	5.12	.101
Naval Weapons Center	2.89	1.71	4.08	.099
Office of Naval Research	3.82	1.14	6.49	.096
Office of Naval Technology	5.89	3.16	8.61	.139

R Square = .937

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 41

Multiple Regression Analysis for Determination of Individual Laboratory
Contribution to Distribution Factor

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
David Taylor Research Center	3.43	2.30	4.56	.114
Naval Air Development Center	2.60	1.34	3.86	.085
Naval Civil Engineering Laboratory	1.31	-1.41	4.03	.016
Naval Coastal Systems Center	6.37	3.99	8.74	.102
Naval Ocean Systems Center	2.87	1.51	4.24	.110
Naval Personnel Research and Development Center	1.59	-2.04	5.22	.016
Naval Research Laboratory	5.60	4.17	7.04	.214
Naval Surface Warfare Center	3.93	2.82	5.05	.141
Naval Training Systems Center	7.56	5.00	10.11	.115
Naval Underwater Systems Center	4.26	2.53	5.99	.106
Naval Weapons Center	2.98	1.65	4.31	.089
Office of Naval Research	2.77	-.22	5.76	.061
Office of Naval Technology	6.36	3.31	9.40	.132
R Square = .939				

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 42

Multiple Regression Analysis for Determination of Individual Laboratory
Contribution to Project Factor

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
David Taylor Research Center	2.87	1.77	3.97	.103
Naval Air Development Center	3.58	2.30	4.87	.122
Naval Civil Engineering Laboratory	.28	-2.39	2.96	.004
Naval Coastal Systems Center	5.18	2.84	7.52	.089
Naval Ocean Systems Center	2.61	1.27	3.95	.106
Naval Personnel Research and Development Center	5.57	2.00	9.14	.060
Naval Research Laboratory	3.70	2.29	5.11	.151
Naval Surface Warfare Center	3.40	2.31	4.50	.131
Naval Training Systems Center	4.22	1.71	6.74	.069
Naval Underwater Systems Center	5.06	3.36	6.76	.135
Naval Weapons Center	3.07	1.77	4.37	.098
Office of Naval Research	1.89	-1.05	4.83	.045
Office of Naval Technology	8.44	5.45	11.42	.189
R Square = .932				

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 43

Multiple Regression Analysis for Determination of Individual Laboratory
Contribution to Credibility Factor

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
David Taylor Research Center	3.81	2.75	4.87	.119
Naval Air Development Center	3.07	1.88	4.26	.094
Naval Civil Engineering Laboratory	3.55	.98	6.12	.040
Naval Coastal Systems Center	6.54	4.30	8.78	.098
Naval Ocean Systems Center	2.96	1.67	4.24	.105
Naval Personnel Research and Development Center	4.91	1.48	8.34	.046
Naval Research Laboratory	5.31	3.95	6.67	.189
Naval Surface Warfare Center	4.66	3.61	5.71	.156
Naval Training Systems Center	5.23	2.81	7.64	.074
Naval Underwater Systems Center	4.49	2.86	6.13	.105
Naval Weapons Center	4.33	3.09	5.58	.122
Office of Naval Research	3.98	1.16	6.79	.082
Office of Naval Technology	5.24	2.37	8.12	.102

R Square = .953

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 44

**Multiple Regression Analysis for Determination of Individual Laboratory
Contribution to Channel Factor**

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
David Taylor Research Center	3.34	2.24	4.45	.128
Naval Air Development Center	2.28	1.04	3.53	.085
Naval Civil Engineering Laboratory	.68	-2.00	3.37	.009
Naval Coastal Systems Center	5.46	3.12	7.81	.100
Naval Ocean Systems Center	.84	-.54	2.23	.036
Naval Personnel Research and Development Center	5.79	2.17	9.35	.066
Naval Research Laboratory	5.29	3.87	6.71	.230
Naval Surface Warfare Center	2.91	1.81	4.01	.119
Naval Training Systems Center	4.30	1.77	6.82	.075
Naval Underwater Systems Center	4.19	2.48	5.90	.119
Naval Weapons Center	2.87	1.57	4.17	.099
Office of Naval Research	2.32	-.62	5.27	.059
Office of Naval Technology	7.08	4.08	10.08	.169

R Square = .922

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 45

Multiple Regression Analysis for Determination of Individual Laboratory
Contribution to Navy Success in Providing Innovative Technology

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
David Taylor Research Center	2.72	1.73	3.71	.103
Naval Air Development Center	2.53	1.41	3.64	.094
Naval Civil Engineering Laboratory	1.01	-1.39	3.42	.014
Naval Coastal Systems Center	5.93	3.82	8.03	.107
Naval Ocean Systems Center	3.08	1.88	4.29	.134
Naval Personnel Research and Development Center	5.95	2.74	9.16	.068
Naval Research Laboratory	3.23	1.96	4.50	.140
Naval Surface Warfare Center	3.55	2.57	4.53	.145
Naval Training Systems Center	2.50	.24	4.76	.043
Naval Underwater Systems Center	4.98	3.45	6.51	.142
Naval Weapons Center	3.59	2.43	4.76	.123
Office of Naval Research	2.38	-.32	5.08	.059
Office of Naval Technology	6.07	3.37	8.78	.143
R Square = .939				

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 46

Multiple Regression Analysis for Determination of Technology Area
Contribution to Frequency of Navy Laboratory Success

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
Stealth	2.05	.11	3.98	.048
Directed Energy	5.18	1.36	9.00	.058
Computing Power/Modeling	3.41	.71	6.11	.060
Software Engineering	3.47	2.04	4.90	.108
Fiberoptics and Photonics	1.21	-.79	3.20	.027
Nonconventional Energy	2.62	-2.32	7.56	.027
Superconductivity	5.50	1.10	9.90	.063
Autonomous Vehicles	3.83	1.45	6.22	.066
Submarine Detection	3.24	1.05	5.44	.070
Cooperative Engagement Technology	4.14	2.14	6.13	.103
Application of Engineered Materials	3.62	2.30	4.95	.100
Information Management and Decision-Making	2.68	1.59	3.78	.091
Environmental Sciences	4.97	2.50	7.43	.096
Insensitive Highly Energetic Materials	2.85	.61	5.09	.046
Simulation Technology	4.42	2.42	6.42	.103
Space-Based Systems	2.66	1.19	4.13	.062
Multi-Static Systems	3.93	1.26	6.60	.071
Advanced Sensors	4.44	2.22	6.66	.095
Range and Test Technologies	4.87	3.06	6.68	.118
R Square = .939				

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

Table 47

Multiple Regression Analysis for Determination of Technology Area
Contribution to Frequency of Private Industry Success

Navy R&D Organization	Coeff.	95% Confidence Interval		Beta
Stealth	3.18	1.46	4.91	.069
Directed Energy	2.57	-.85	5.99	.027
Computing Power/Modeling	6.46	4.08	8.84	.106
Software Engineering	2.71	1.41	4.01	.080
Fiberoptics and Photonics	3.30	1.36	5.23	.069
Nonconventional Energy	3.50	-.81	7.81	.033
Superconductivity	7.47	3.60	11.35	.080
Autonomous Vehicles	2.64	.49	4.78	.043
Submarine Detection	2.54	.64	4.44	.052
Cooperative Engagement Technology	5.45	3.66	7.25	.124
Application of Engineered Materials	2.79	1.66	3.93	.075
Information Management and Decision-Making	3.50	2.51	4.49	.109
Environmental Sciences	5.38	3.18	7.58	.095
Insensitive Highly Energetic Materials	3.32	1.33	5.30	.050
Simulation Technology	3.43	1.90	4.96	.080
Space-Based Systems	3.93	2.60	5.26	.084
Multi-Static Systems	5.69	3.30	8.07	.096
Advanced Sensors	3.26	1.30	5.23	.065
Range and Test Technologies	4.16	2.53	5.78	.093
R Square = .954				

Scale:

1=Never 2=Almost Never 3=Occasionally 4=Frequently
5=Almost Always 6=Always

SUMMARY

This chapter has shown the results of the data analyses that were presented in Chapter 3, Method. Three primary research questions, as well as four other research questions were evaluated. The following chapter, Summary, Conclusions, and Recommendations, will present and discuss the interpretation and implications of these research findings.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Effective management of technology is critical to the defense of the United States, particularly in view of the fact that the Department of Defense is attempting to offset Soviet numerical superiority with superior technology. The key to the success of this strategy is the effective transfer of technology from federal laboratories into fielded defense systems.

However, both the Defense Department and private industry are seriously deficient in their ability to rapidly transition technology into products and systems. This situation is expected to become worse in the future as many traditional management tools and methodologies become invalid in the face of the rapid changes taking place in today's competitive environment (Defense Science Board, 1987).

The application of Management of Technology theory and methods could provide an effective conceptual framework to aid in understanding the evolving relationships and processes in this new environment. However, the Management-of-Technology field is not generally well recognized or even consistently defined. Additionally, there has been very little systematic attention being paid to Management-of-Technology issues within the federal agencies (National Research Council, 1987).

This study supported the further development of the understanding of technology transfer, one of the specific areas delineating the Management-of-Technology field. The study, conducted within the context of the Navy research and development community, analyzed the technology transfer performance of various for-profit and not-for-profit technology supplier and technology user organizations.

Due to the relatively distinct separation of research and development responsibilities organizationally within the Department of Navy this study was able to specifically address technology transfer occurring in the middle ground of the research and development spectrum, that is its transfer between targeted research, exploratory development, and advanced development. This area was identified by Burte as one in particular need of study because it is where the least amount of attention has been focused in the past (American Association of Engineering Societies, 1987).

In addition, this evaluation focused on the recipient, or user, of new technology, an area identified by Talaysum (1985) and Essoglou (1980) as additionally requiring further study.

A researcher-designed questionnaire was developed to measure various dependent and explanatory variables describing the technology transfer process. A total of 755 questionnaires were sent to key technical personnel in Department of Defense organizations which were responsible for, or heavily influenced, the acquisition and implementation of new and innovative technology in Navy equipments and weapon systems. These organizations included the Defense Advanced Research Projects Agency (DARPA), Naval Air Systems Command (NAVAIR), Naval Sea Systems Command (NAVSEA), and the Space and Naval Warfare Systems Command (SPAWAR).

Each questionnaire was mailed with a cover letter explaining the purpose of the study and signed by the Director of Navy Laboratories, and a postcard to indicate a return address for a copy of the study results. Three hundred forty-two usable responses were received, which represented a 45 percent response rate.

All data generated were ratio or interval data, except for the nominal organization classification. The data analysis procedures included Chi-square tests for response bias, ordinary-least-squares multiple linear regression to test for the presence of significant linear relationships, t-Tests to test for mean differences, and one-way analysis-of variance (ANOVA) with post hoc Scheffe procedures to test for individual mean

differences. An analysis technique described by Zar (1974) was used to determine if various multiple regressions estimated the same population regression function. The significance of relationships was tested at the $\alpha=.05$ level.

Assumptions made in this study were centered around the ability of the various factors in the Technology Transfer Hypothesis to accurately describe the technology transfer process within the Navy research and development community. The validity of this assumption was addressed in this study.

CONCLUSIONS

The following sections present the conclusions of this study. Following an analysis of the sample respondents, the discussion progresses in the order of the research questions as presented in earlier chapters.

Description Of The Sample

Chapter 3 presented a detailed description of the sample population including professional qualifications, level of interaction with various technology provider communities and organizations, and level of involvement in each of several technology areas. The following sections draw upon this data.

Usable Responses. The high percentage of usable responses received from each of the four technology user organizations gave adequate evidence to the existence of a high level of interest in, and appreciation for the importance of efficient and effective technology transfer within the Navy research and development community. Indeed, over half of the respondents requested copies of the study results.

Further significance to this conclusion was provided by the substantial professional experience of the average respondent who possessed over 21 years of professional service.

Analysis of the last 25 received questionnaires revealed that those personnel who were among the last to return their questionnaires rated themselves as having been significantly less successful in acquiring and implementing new and innovative technology, when compared with all earlier respondents. No other significant differences existed. The correlation of late submission and below average performance suggests that the presence of individual work habits, such as timeliness and responsiveness, may have a broad and fairly profound impact upon organizational performance.

Respondent Organization Interaction With Technology Providers. The Defense Advanced Research Projects Agency reported a fairly consistent level of interaction with universities and the various Department of Defense laboratories indicating a willingness and desire to work across the board with a broad spectrum of potential innovation suppliers. The level of interaction with private industry however was markedly higher possibly indicating higher responsiveness or quality of effort from the private sector.

Specifically within the Navy laboratory community the Defense Advanced Research Projects Agency focused its primary interaction on the Naval Ocean Systems Center, Naval Research Laboratory, and the Office of Naval Technology. (While the Office of Naval Technology is not an actual laboratory but in fact a technology management organization, it was included within this category due to its key role as a focal point for ongoing laboratory activities.) It was believed that the characteristically broad mission of these organizations was responsible for this focused interaction.

The Navy Systems Commands (consisting of the Naval Air Systems Command, Naval Sea Systems Command, and Space and Naval Warfare Systems Command) focused their primary interactions on the Navy laboratory community. This result was not unexpected since it is the primary mission of the laboratories to support these organizations.

The Systems Commands level of interaction with private industry was reported as only slightly lower than with the Navy laboratories, indicating significantly less reliance on the private sector than was indicated by the Defense Advanced Research Projects Agency.

The correlation of various mission and platform responsibilities between the individual Systems Commands and specific Navy laboratories accounted for numerous instances of emphasized interaction. Some of these key alignments included: (1) the Naval Air Systems Command and the Naval Air Development Center, and Naval Weapons Center; (2) the Naval Sea Systems Command and the David Taylor Research Center, and Naval Surface Warfare Center; and (3) the Space and Naval Warfare Systems Command and the Naval Ocean Systems Center, and Naval Research Laboratory.

Respondent Organization Involvement By Technology Area. The extent of involvement reported by the respondent organizations in specific technology areas largely reflected the scope of the mission responsibilities of respective organizations. For example the Space and Naval Warfare Systems Command, whose mission includes command and control, reported heavy involvement in Software Engineering, Cooperative Engagement Technology, and Information Management and Decision-making.

Additionally, several technologies which possessed broad applicability to a wide variety of mission areas were found to have been reported in use by all the responding organizations. Fiber optics and Photonics represented a good example of such a broad-based technology.

Technology Transfer Hypothesis

The process of technology transfer within the Navy research and development community was analyzed by this study as a two phase process. The first phase or step toward potential implementation is the successful communication of information describing new and innovative technology, or scientific know-how, from a technology provider to the potential technology user. In the context of this study the potential technology providers consisted of Navy laboratories and Private industry; the potential technology users consisted of the Defense Advanced Research Projects Agency and the Navy Systems Commands.

The second phase of this process is the actual implementation of selected innovative technologies in new designs, or upgrades to existing Navy equipments and weapon systems in order to provide improved or increased implementation of selected innovative technologies in new designs, or upgrades to existing Navy equipments and weapon systems in order to provide improved or increased capabilities. It should be noted that while the technology user organizations in this study have direct management responsibility for such implementation, the technology provider typically continues to play an active and vital role as technical consultant or advisor throughout the implementation process.

The Technology Transfer Hypothesis sought to determine the relationship between various organizational characteristics and technology transfer success occurring during each phase of this two-step process. With regard to the first phase of overall technology transfer process, the hypothesized factors were able to account for approximately 55 percent of the success of Navy laboratories and private industry in providing new and innovative technology to potential technology users.

The following factors and organizational characteristics were found to possess a significant positive influence on successful technology transfer: (1) clear documentation of the technology in a format and at a level of detail appropriate to the technology user's needs; (2) consideration by the technology developer of the potential user's technology needs when undertaking new research and development projects; (3) high technical credibility and reliability of the technology supplier organization; and, (4) the user of repeatable and well-defined communication channels.

For technology originating from Navy laboratories it was found that an additional factor, the existence of an organizational climate supportive of the investigation and use of new and innovative technology by the technology user organization, also had a significant positive influence on technology transfer success. Viewed alternatively, this would indicate the presence of an additional barrier to technology transfer success for the Navy laboratories, a barrier which was not found to be present for private industry.

With regard to the entire technology transfer process, which encompasses both the communication flow of new technology information as well as its actual implementation, the technology transfer model was able to account for approximately 50 percent of technology user success.

The following technology supplier characteristics were found to possess a significant positive influence on the technology user's successful acquisition and implementation of new and innovative technology: (1) clear documentation of the technology in a format and at a level of detail appropriate to the user's needs; (2) high technical credibility and reliability; and, (3) the use of repeatable and well-defined communication channels.

It was also found that easy access by the technology user to needed technical information had a significant negative effect on successful technology transfer, implying successful transfer of technology is fostered by limited information flow with the technology provider. Such a conclusion is highly suspect and warrants further discussion.

The intra-government relationship that exists between the technology users and the Navy laboratories provides for significantly freer information flow than with private industry, where the nature of legal and contractual relationships constrain information exchange. The extent of this fundamental difference in communication freedom may indeed have masked the smaller but potentially beneficial effects of unrestricted information flow.

Another possible explanation for this anomaly is that technology users who become closely aligned with a technology supplier, possibly in an attempt to further refine the technology, or better understand its potential applications, relegate its actual implementation to a secondary concern.

Alternatively the technology user may be continuously distracted from implementation by the rapid pace of tempting new scientific developments which, if acquired, could further enhance system capability.

Several factors relating to characteristics of the technology user organization were additionally found to possess a significant positive effect on successful technology implementation. These factors included: (1) personnel with the education, skills and traits necessary to seek out and implement new and innovative technology; (2) personnel with a willingness and desire to seek new and innovative solutions to system requirements; (3) promotions for personnel who pursue new ideas, processes, or products; and, (4) an organizational climate supportive of the investigation and use of new and innovative technology.

It was also found that technology information arriving through repeatable and well-defined communication channels had a significant negative effect on successful technology implementation. Thus while well-structured communication channels have been shown to be beneficial for initially conveying new technology information, well-defined and repeatable channels of communication act as a barrier to success during the implementation phase.

This finding corroborated the earlier observation that easy access to new technology information acted as a barrier to success during the implementation phase. This result also gives further weight to a

previously proposed explanation that technology users who become closely focused on new technology developments relegate actual implementation to a secondary consideration.

Since the technology transfer model was unable to fully account for technology transition success, consideration must be given to the identification of additional explanatory factors. Certainly the personal characteristics and behaviors of the individuals involved in this process may indeed play a very significant role in explaining the remaining 50 percent of technology transition success.

Technology Dependence Hypothesis

There was reason to suspect that the process of technology transfer may, depending upon the nature and specific characteristics of the technology involved, possess different attributes. For example, the process describing the transformation of new innovations in fiber optic components into fielded products may be different than the transformation process for newly developed software.

The Technology Dependence Hypothesis sought to determine if the importance of the various factors in the technology transfer model was related to the type of technology involved. The seven categorizations of technology listed below, based upon varying technology attributes and characteristics, such as process versus product technology, were chosen and analyzed. The results of this analysis revealed that the process of acquisition and implementation of new and innovative technology was not related to the type of technology involved.

1. Computer Technology—including computing power/modeling; software engineering, cooperative engagement technologies, information management and decision-making, and simulation technology.
2. Software Technology—including software engineering and information management and decision-making.
3. Command, Control, and Communications Technology—including cooperative engagement technologies and space-based systems.
4. Fiber optics and Photonics Technology—including fiber transmission lines, optical sources, sensors and components.
5. Advanced Sensor Technology—including transducers and electromagnetic devices, and navigation sensors.
6. Space-based System Technology—including communications, surveillance, and data processing.
7. Autonomous Vehicle Technology—including guidance and control, automatic targeting, intelligent subsystems, and telecommunications.

Financial Dependence Hypothesis

Considerable conflicting literature exists addressing similarities and differences in the behavior and performance of for-profit and not-for-profit organizations. A common thread running through studies addressing similarities between these organizations was the belief that the complexity of the business environment has grown to a point where it has overshadowed the single dimension of a business' legal status.

With regard to explanations of differences in these organizations Cyert and March (1963), Newman and Wallender (1978), and Ott (1980) have noted that distinctions between for-profit and not-for-profit

organizations have been based upon the existence of directly quantifiable measures such as sales and inventory level. However, scientific knowledge, which is the product of research and development organizations, is difficult to quantify. Thus the for-profit versus not-for-profit distinction may not be applicable in the context of this study.

While the Navy laboratories were correctly categorized as not-for-profit organizations, the Navy Industrial Fund accounting system under which they operate did require the identification of specific customer, or technology user funds for reimbursement of incurred costs such as labor, material, etc. Such an economic system which requires the expenditure of limited-available funds for Navy laboratory services shares strong similarities to the for-profit business sector.

The Financial Dependence Hypothesis evaluated in this study sought to address the relative technology transfer performance of for-profit organizations, as represented by private industry technology providers, versus not-for-profit organizations, as represented by the Navy laboratories.

Comparisons were made between various individual Navy laboratory and private industry characteristics which influenced technology transfer success. Analysis of this data indicated two distinct schools of thought among the responding organizations. The Defense Advanced Research Projects Agency and the Space and Naval Warfare Systems Command each viewed private industry as significantly more in possession of traits which foster successful technology transfer. Additionally when asked to directly evaluate the success of the Navy laboratories versus private industry in providing innovative technology, these two organizations both strongly indicated a higher frequency of success from private industry.

The Naval Air Systems Command and the Naval Sea Systems Command comprised the other school of thought. They saw both the Navy laboratories and private industry in equal possession of traits which influence technology transfer. Consistent with their opinions of the various traits they also perceived no significant difference when asked to directly compare Navy laboratory versus private industry success in supplying innovative technology.

Several explanations for the lack of agreement among the respondent organization evaluations are possible. One possible explanation stems from the fact that each of the responding organizations indicated interaction with a different mix of both Navy laboratories and private industry firms. Consequently the differences in the respondent evaluations may have reflected characteristics and performance differences among the individual technology provider organizations.

A possible explanation for the higher private industry evaluations provided by the Defense Advanced Research Projects Agency is that numerous key technical personnel in that organization have historically been hired directly from the private sector, and thus possessed established working relationships with that community as well as opinions which may understandably influence their assessments. Such a conclusion is further supported by the organization's significantly higher level of interaction with private industry.

By way of comparison, personnel in the Navy Systems Commands generally represented the career civil servant and typically have had little, if any, recent private industry employment experience.

Such explanations however do not discount the conclusion that private industry has, at least in some cases, been evaluated as more successful than the Navy laboratories both in supplying innovative technology as well as providing support for its implementation in new or upgraded equipments.

Other Hypotheses

Additional hypotheses were also investigated by this study in order to provide a more complete understanding of the technology transfer process within the Navy research and development community. These additional hypotheses are discussed in the following sections.

Technology User Differences. Analyses were also conducted to evaluate the relative technology transfer performance of the respondent technology user organizations. Information describing the various organizational characteristics which influence technology transfer success was compared.

Analysis of this data indicated that the Defense Advanced Research Projects Agency consistently rated itself higher than each of the the Navy System Commands in the possession of those traits which foster successful technology transfer. Consistent with these evaluations this organization also rated itself significantly more successful in acquiring and implementing new and innovative technology.

Only a limited number of differences in organizational traits which affect technology transition performance were observed among the Navy Systems Commands. These conclusions regarding differences among technology user organizations are not surprising in view of the above average education, recognized degree of technical expertise, and relatively high financial authority typically given to individuals within the Defense Advanced Research Projects Agency.

Technology User Dependence. Analyses were also performed to understand the relationship between the supply overall ability of new scientific knowledge and technology user success in acquiring and implementing new and innovative technology. Separate analyses were conducted for each of the four technology user organizations.

Analysis of the Defense Advanced Research Projects Agency and Space and Naval Warfare Systems Command indicated no meaningful dependence of implementation success on the availability of new and innovative technology. This inability to observe an expected positive input-output relationship may indicate input over-saturation, that is that these organizations have been provided with more new technology than they are capable of implementing.

Alternatively, such a finding would not be inconsistent with the existence of other significant influences, such as internal organizational pressures, which might override the apparent availability of new scientific knowledge.

Another possible explanation for the absence of this expected relationship is the significant amount of time that typically transpires between the arrival of new technology information and the time of its actual implementation, resulting in an apparent input-output decoupling. Such time delays could reasonably be expected to be measured in terms of years.

Analyses of information describing the Naval Air Systems Command and the Naval Sea Systems Command provided a somewhat more descriptive picture of their technology input-implementation output relationships. In both cases the availability of new technology had a clearly positive and significant effect on successful technology implementation. It was, however, clear in these cases that the availability of new technology played only a small part in the final determination of implementation success.

Individual Navy Laboratory Performance. Assessments made by the responding organizations of overall Navy laboratory performance were statistically decomposed into individual laboratory assessments. The decomposition technique used oversimplified to some degree the actual human evaluation process. However, the technique does respond, if only partially, to the need for a method to evaluate individual laboratory performance.

The Office of Naval Research and Office of Naval Technology, while not actually laboratories but more correctly science and technology management organizations, were included within the category of Navy laboratories due to their key role as focal points for ongoing laboratory activity.

Two measures of individual laboratory performance have been provided. The first measure represents a level of qualitative performance which is irrespective of the size or level of effort of that laboratory. The second measure provides an indication of the importance or magnitude of the contribution of that laboratory toward overall Navy laboratory performance. As such this value represents a combination of both the quality of performance and the magnitude of effort.

Summarized results of this analysis showing the rank order of the individual laboratories for both measures are provided in Tables 48 and 49, respectively.

The Office of Naval Technology was seen as the most consistently highly rated organization in terms of technology transfer model characteristics which enhance technology transfer. Additionally, due to the large degree of interaction of this organization with the various technology users, the Office of Naval Technology was also the most consistently highly rated organization in terms of the importance of its contribution toward overall Navy performance.

The Naval Coastal Systems Center, one of the smaller organizations in the Navy laboratory community, was also seen as consistently possessing many of the characteristics which contribute to success in technology transfer. Consistent with this finding that laboratory was also highly rated in its success in providing new and innovative technology. Possibly the relatively narrow customer base of this organization has allowed it to better focus its efforts and resources on the specific needs of the technology user.

From the perspective of importance of individual laboratory contribution toward overall Navy performance, the Naval Surface Warfare Center was also consistently highly rated in terms of technology transfer model characteristics. In addition this laboratory was also the most highly rated in terms of importance of its contributions toward overall Navy success in providing innovative technology.

Individual Technology Performance. Analyses were also conducted to determine the contributions of each of nineteen technology areas toward Navy laboratory and private industry success in providing innovative technology to the respondent organizations.

Two measures of technology area success have been provided. The first measure represents a level of qualitative performance which is irrespective of the level of effort being pursued in that area. The second measure provides an indication of the importance or degree of contribution of that technology area toward overall Navy laboratory or private industry success in supplying new and innovative technology. Accordingly this value represents a combination of both performance quality and the magnitude of effort.

Summarized results of this analysis showing the rank order of the individual technology areas for both measures are provided in Tables 50 and 51, respectively.

With regard to the individual technology area success for Navy laboratories, two areas received notably high ratings: (1) Superconductivity, including materials and sensors, and; (2) Directed Energy schemes providing intense focused energy capability. At the other extreme Fiberoptics and Photonics, including fiber transmission lines, optical sources, sensors, and components received a very low rating.

Analysis of individual technology area success for private industry indicated two areas which received substantially high ratings: (1) Superconductivity, including materials and sensors, and; (2) Computing Power and Modeling encompassing massive parallel processing, connection machines, and high speed computational engines.

Table 48

**Rankings of Navy Laboratories in Individual Frequency of
Technology Transfer Factors and Individual Success in
Providing Innovative Technology**

Navy Laboratory	DOC	DIST	PROJ	CRED	CHAN	SUC
David Taylor Research Center	10	7	10	10	7	9
Naval Air Development Center	9	11	7	12	11	10
Naval Civil Engineering Laboratory	12	13	13	11	13	13
Naval Coastal Systems Center	3	2	3	1	3	3
Naval Ocean Systems Center	13	9	11	13	12	8
Naval Personnel Research and Development Center	2	12	2	5	2	2
Naval Research Laboratory	4	4	6	2	4	7
Naval Surface Warfare Center	8	6	8	6	8	6
Naval Training Systems Center	7	1	5	4	5	11
Naval Underwater Systems Center	6	5	4	7	6	4
Naval Weapons Center	11	8	9	8	9	5
Office of Naval Research	5	10	12	9	10	12
Office of Naval Technology	1	3	1	3	1	1

Legend:

DOC - Clear documentation of the technology in a usable format and at an appropriate level of detail.

DIST - Ease of access to needed technical documentation or technical experts.

PRO - consideration by the technology developer of the customer's performance requirements when undertaking new R&D projects.

CRED - Credibility and reliability of the organization which is developing the new technology.

CHAN - Structured or well defined communication channels for new technology information to enter an organization.

SUC - Overall success in providing innovative technology to meet performance design requirements.

Table 49

Rankings of Navy Laboratories in Importance of Contribution to Overall
Navy Frequency of Technology Transfer Factors and Overall
Navy Success in Providing Innovative Technology

Navy Laboratory	DOC	DIST	PROJ	CRED	CHAN	SUC
David Taylor Research Center	14	5	7	4	3	8
Naval Air Development Center	5	10	5	9	8	9
Naval Civil Engineering Laboratory	13	13	13	13	13	13
Naval Coastal Systems Center	9	8	9	8	6	7
Naval Ocean Systems Center	10	6	6	4	12	5
Naval Personnel Research and Development Center	12	12	11	12	10	11
Naval Research Laboratory	1	1	2	1	1	4
Naval Surface Warfare Center	3	2	4	2	4	1
Naval Training Systems Center	11	4	10	11	9	12
Naval Underwater Systems Center	6	7	3	6	5	3
Naval Weapons Center	7	9	8	3	7	6
Office of Naval Research	8	11	12	10	11	10
Office of Naval Technology	2	3	1	7	2	2

Legend:

DOC - Clear documentation of the technology in a usable format and at an appropriate level of detail.

DIST - Ease of access to needed technical documentation or technical experts.

PRO - consideration by the technology developer of the customer's performance requirements when undertaking new R&D projects.

CRED - Credibility and reliability of the organization which is developing the new technology.

CHAN - Structured or well defined communication channels for new technology information to enter an organization.

SUC - Overall success in providing innovative technology to meet performance design requirements.

Table 50

**Rank by Technology Area of Navy Laboratory
and Private Industry Success in Providing
Innovative Technology**

Technology Area	Navy Laboratory Success	Private Industry Success
Stealth	18	14
Directed Energy	2	18
Computing Power/Modeling	12	2
Software Engineering	11	16
Fiberoptics and Photonics	19	12
Nonconventional Energy	17	9
Superconductivity	1	1
Autonomous Vehicles	9	17
Submarine Detection	13	19
Cooperative Engagement Technology	7	4
Application of Engineered Materials	10	15
Information Management and Decision-making	15	8
Environmental Sciences	3	5
Insensitive Highly Energetic Materials	14	11
Simulation Technology	6	10
Space-based Systems	16	7
Multi-static Systems	8	3
Advanced Sensors	5	13
Range and Test Technologies	4	6

Table 51

Rank of Importance of Technology Areas in Overall Success in
Providing Innovative Technology

Technology Area	Navy Laboratory Success	Private Industry Success
Stealth	16	13
Directed Energy	15	19
Computing Power/Modeling	14	3
Software Engineering	2	8
Fiberoptics and Photonics	18	12
Nonconventional Energy	19	18
Superconductivity	12	9
Autonomous Vehicles	11	17
Submarine Detection	10	15
Cooperative Engagement Technology	4	1
Application of Engineered Materials	5	11
Information Management and Decision-making	8	2
Environmental Sciences	6	5
Insensitive Highly Energetic Materials	17	16
Simulation Technology	3	10
Space-based Systems	13	7
Multi-static Systems	9	4
Advanced Sensors	7	14
Range and Test Technologies	1	6

From the perspective of importance of individual technology area contributions to the determination of overall Navy laboratory success in providing new scientific knowledge four key areas were identified: (1) Range and Test Technologies including measurement and processing of acoustic and electromagnetic signatures and signals; (2) Software Engineering encompassing large-scale algorithmic systems, protocol communication among multi-processors, and artificial intelligence and expert system algorithms; (3) Cooperative Engagement Technology providing inter-platform command control and communication, real-time data management and fusion, and displays, and; (4) Simulation Technology covering large-scale interactive models, hardware-in-the-loop simulation and stimulation, and training.

As viewed by the importance of individual technology area contributions to overall private industry success in providing new and innovative technology three areas were seen as major contributors: (1) Cooperative Engagement Technology including inter-platform command, control and communications, real-time data management and fusion, and displays; (2) Information Management and Decision-making covering the application of statistics and logical decision elements, expert and computer-aided systems including neural networks, and; (3) Computing Power and Modeling including massive parallel processing, connection machines, and high speed computational engines.

Evaluation of the Study

This section provides an evaluation of this study. The strengths and limitations are discussed below.

Strengths. This study was based upon an analysis of real-world conditions as viewed by working level personnel in organizations which represent the context of this study. In addition, those personnel performing the evaluations typically possessed long standing experience in their respective professional fields.

Limitations. Every research study has some limitations that should be clearly stated to insure that the results are evaluated properly and not overly generalized. This study has two limitations that were observed: the specialized nature of the target population, and the accuracy of the organizational responses.

The target population for this study represented a very specialized category of research and development activity. The parameters within which any federal organization is free to act are established by law or regulation. Since the Federal Government is the largest public organization in the United States, it possesses the most extensive body of laws and regulation. Therefore the results of this study should be applied to other categories of organizations only after insuring that no major conceptual differences exist that would limit the application of the basic research model.

This study relied on the subjective evaluations of the respondents to provide an accurate description of organizational characteristics and behaviors. It assumed that their responses would be candid and honest. A more objective approach to data collection could have removed any personal biases or preconceptions that may have been presents. As an example, the identification in the questionnaire of the organization conducting this study could have been withheld to remove any possible biases the respondent had regarding that organization.

The design of this study considered the Defense Advanced Research Projects Agency as solely a technology user organization, while it more accurately also plays a significant role as a technology provider, sponsoring and coordinating a substantial amount of research and development effort. Indeed several of the questionnaires returned from this organization contained hand written notes to that effect in the questionnaire margins.

RECOMMENDATIONS

This study provided a number of practical implications for the practice of management. In addition there are several suggestions for future research in this area of technology transition.

Implications for the Practice of Management

There are a number of practical lessons learned in this study that can be applied by managers who deal with innovative technology. This study was not the result of an artificial situation or experiment, but rather was based upon an analysis of real-world conditions that many managers must deal with on a daily basis. The following are some of the most significant implications resulting from this study:

1. The Navy laboratory community can perform in a manner that overall compares quite favorably with private industry in providing new and innovative technology for new equipments and weapon systems.
2. The Navy laboratories and private industry each possess a unique set of specialized skills and expertise covering the various technology areas.
3. Managers must constantly be aware of the organizational and behavioral characteristics which foster and enhance effective technology transfer. Establishment of appropriate procedures for institutionalization of these characteristics should be a conscious and deliberate effort.
4. The design, approach, and questionnaire format used in this study could be used to evaluate the technology transition environment of other Department of Defense organizations.

Suggestions for Future Research

Future research in the field of technology transfer should address the specific issue of interaction of the various variables that comprise the technology transfer mechanism.

The refinement of a generic technology transfer model to fit the specifics of Department of Defense organizations may well be warranted in view of the magnitude of the research and development efforts ongoing in this sector.

The self evaluations by the Defense Advanced Research Projects Agency differed notably from those made by the Navy Systems Commands. However no attempt was made by this study to understand the basis for these differences. A more complete understanding of such differences may shed further light into the process by which scientific knowledge is transferred from research and development laboratories to fielded systems. Further research into the inner workings of these organizations could be fruitful.

The concepts demonstrated in this study have the potential of providing more insight into the technology transition behavior of various Department of Defense organizations and improving their performance if these concepts can be generalized to other organization types. Such studies should be focused on the need to develop practical working methodologies that can be used by the managers of such organizations.

One of the strongest and most valuable resources this nation possesses is its pool of talented scientists and engineers. However, their efforts alone will not be sufficient to maintain the United States current position of world technological leadership. Managers who understand and appreciate the nature of technology development must be able to swiftly guide the transformation of invention and innovative effort into needed products and processes. This is our nation's weakness. It is today's management challenge.

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APPENDIX A
QUESTIONNAIRE

Technology Transition Environmental Assessment

GENERAL INSTRUCTIONS

This study was designed to obtain your assessment of the ability of various R&D organizations to provide new and innovative technology to organizations such as yours. The questionnaire has three sections: Section A identifies the technology source organizations with which you interact; Section B identifies applicable technology areas; and Section C assesses the potential to transition new technology from various R&D organizations.

This information is not an individual activity rating or an inspection, and your organizational code or office will not be identified in the final report. If you would like a copy of the results of this survey mailed to you, please fill out and mail in the enclosed postcard.

After completing this questionnaire please return it in the pre-addressed envelope enclosed. Thank you for your time and cooperation.

Section A - Technology Source Identification

Never
Almost Never
Occasionally
Frequently
Almost Always
Always

1. Please indicate how often your code or office interacts with each of the following R&D communities when seeking innovative technology to meet existing or anticipated design requirements.

Navy Laboratories	N	AN	O	F	AA	A
Air Force Laboratories	N	AN	O	F	AA	A
Army Laboratories	N	AN	O	F	AA	A
Department of Energy National Laboratories	N	AN	O	F	AA	A
NASA Laboratories and Centers	N	AN	O	F	AA	A
Universities and University Affiliates	N	AN	O	F	AA	A
Private Industry	N	AN	O	F	AA	A
Other (please specify: _____)	N	AN	O	F	AA	A

2. How often does your code or office interact with each of the following specific Navy R&D organizations when seeking innovative technology to meet existing or anticipated design requirements?

David Taylor Research Center (DTRC)	N	AN	O	F	AA	A
Naval Air Development Center (NADC)	N	AN	O	F	AA	A
Naval Civil Engineering Center (NCEL)	N	AN	O	F	AA	A
Naval Coastal Systems Center (NCSC)	N	AN	O	F	AA	A
Naval Ocean Systems Center (NOSC)	N	AN	O	F	AA	A
Naval Personnel Research and Development Center (NPRDC)	N	AN	O	F	AA	A
Naval Research Laboratory (NRL)	N	AN	O	F	AA	A

Section A (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
Naval Surface Warfare Center (NSWC)	N	AN	O	F	AA	A
Naval Training Systems Center (NTSC)	N	AN	O	F	AA	A
Naval Underwater Systems Center (NUSC)	N	AN	O	F	AA	A
Naval Weapons Center (NWC)	N	AN	O	F	AA	A
Office of Naval Research (ONR)	N	AN	O	F	AA	A
Office of Naval Technology (ONT)	N	AN	O	F	AA	A

If you have indicated that your code or office never seeks innovative technology from any of the sources identified in questions 1 or 2, then you do not need to proceed further. For completeness of the survey records please return the questionnaire in the pre-addressed envelope provided. Thank you for your cooperation.

If you have indicated that you do seek innovative technology, please continue to the next question.

3. When seeking innovative technology, if you interact with any Navy R&D activities not listed in question 2, please list them here:

4. If you interact with private industry when seeking innovative technology, please identify key companies here:

Section B - Technology Area Identification

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
5. How often is your code or office involved in the following technology areas?						
Stealth (acoustic and electromagnetic signature reduction, including active and passive countermeasures)	N	AN	O	F	AA	A
Directed Energy (weapons schemes with intense focused energy)	N	AN	O	F	AA	A
Computing Power/Modeling (massive parallel processing, connection machines, high speed computational engines, etc)	N	AN	O	F	AA	A
Software Engineering (large-scale algorithmic systems, protocol communication among multi-processors, AI and expert system algorithms)	N	AN	O	F	AA	A
Fiberoptics and Photonics (fiber transmission lines, optical sources, sensors and components)	N	AN	O	F	AA	A
Nonconventional Energy (high-density energy storage, electromagnetic thrusters)	N	AN	O	F	AA	A
Superconductivity (materials, sensors, electric machinery)	N	AN	O	F	AA	A
Autonomous Vehicles (guidance and control, automatic targeting, intelligent subsystems, telecommunications)	N	AN	O	F	AA	A
Submarine Detection (active and passive, acoustic and non-acoustic)	N	AN	O	F	AA	A
Cooperative Engagement Technologies (inter-platform command control and communications, real-time data management and fusion, displays)	N	AN	O	F	AA	A
Application of Engineered Materials (biotechnology, coating materials, solid-fluid interaction, structural designs)	N	AN	O	F	AA	A

Section B (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
Information Management and Decision-making (application of statistics and logical decision elements, expert and computer-aided systems including neural networks)	N	AN	O	F	AA	A
Environmental Sciences (undersea and atmospheric propagation)	N	AN	O	F	AA	A
Insensitive Highly Energetic Materials (safe explosives and propellants)	N	AN	O	F	AA	A
Simulation Technology (large-scale interactive models, hardware-in-the-loop simulation and stimulation, training)	N	AN	O	F	AA	A
Space-based Systems (communications, surveillance, and data processing)	N	AN	O	F	AA	A
Multistatic Systems (all active sonars, acoustic and electromagnetic transmission)	N	AN	O	F	AA	A
Advanced Sensors (transducers and electromagnetic devices, navigation sensors)	N	AN	O	F	AA	A
Range and Test Technologies (measurement and processing of acoustic and electromagnetic signatures and signals)	N	AN	O	F	AA	A

Section C - Technology Transition Assessment

Not Important → Very Important

6. How important do you think each of the following factors are in the successful transition of new technology from R&D laboratories to 'technology user' organizations such as yours?

Clear documentation of the technology in a usable format and at an appropriate level of detail.

1 2 3 4 5 6

Ease of access to needed technical documentation or technical experts.

1 2 3 4 5 6

A supportive organizational climate which fosters the investigation and use of innovative new technology.

1 2 3 4 5 6

Consideration by the technology developer of the desired system performance requirements when undertaking new R&D projects.

1 2 3 4 5 6

The capacity and skills in the technology user organization to understand and apply new technology.

1 2 3 4 5 6

The credibility and reliability of the organization developing the new technology.

1 2 3 4 5 6

The presence of individuals who carry the news of useful new technologies to various potential users.

1 2 3 4 5 6

The willingness or internal motivation of individuals to search out and investigate the potential use of new technology.

1 2 3 4 5 6

Tangible and intangible rewards to those who pursue the adoption of innovative ideas and technology.

1 2 3 4 5 6

Structured or well defined communication channels for new technology information to enter an organization.

1 2 3 4 5 6

Section C (con't)

Never
Almost Never
Occasionally
Frequently
Almost Always
Always

7. Please indicate how often each of the following statements is true regarding your immediate organization.

Engineers in my group possess the education, skills and traits necessary to seek out and implement new and innovative technology.

N AN O F AA A

My colleagues discuss new and innovative technology developments.

N AN O F AA A

Members in my group seek new and innovative solutions to system performance requirements.

N AN O F AA A

Employees in my group that pursue new ideas, processes or products get promoted faster than their colleagues.

N AN O F AA A

My immediate organization is supportive of the investigation and use of new and innovative technology.

N AN O F AA A

My group has been successful in acquiring and implementing new and innovative technology.

N AN O F AA A

8. Please indicate how often each of the following statements is true regarding the companies in private industry with which you interact. (If you do not interact with any companies in private industry skip this question and go on to the next one.)

Industry generates clear documentation of new technology in a format and at a level of detail appropriate to my needs.

N AN O F AA A

Industry allows easy access to needed technical documentation and information.

N AN O F AA A

Companies in private industry consider my technology needs when undertaking new R&D projects.

N AN O F AA A

Section C (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
The technical credibility and reliability of the companies I interact with is very high.	N	AN	O	F	AA	A
New technology information from industry comes through repeatable and well-defined channels of communication.	N	AN	O	F	AA	A
Private industry has been successful in providing innovative technology to meet my system performance requirements.	N	AN	O	F	AA	A
9. Please indicate how often each of the following statements is true regarding the <u>Navy laboratories</u> with which you interact. (If you do not interact with any Navy labs skip this question.)						
The Navy labs generate clear documentation of new technology in a format and at a level of detail appropriate to my needs.	N	AN	O	F	AA	A
Navy labs allow easy access to needed technical documentation and information.	N	AN	O	F	AA	A
Navy labs consider my technology needs when undertaking new R&D projects.	N	AN	O	F	AA	A
The technical credibility and reliability of the Navy labs I interact with is very high.	N	AN	O	F	AA	A
New technology information from Navy labs comes through repeatable and well-defined channels of communication.	N	AN	O	F	AA	A
The Navy labs have been successful in providing innovative technology to meet my system performance requirements.	N	AN	O	F	AA	A

Section C (con't)

10. Please provide the following information:

Your organization (check one): DARPA _____

NAVAIR _____

NAVSEA _____

SPAWAR _____

Number of years professional experience: _____

Number of years in your present position: _____

Again, thank you for your time and cooperation. Please return this questionnaire in the pre-addressed envelope enclosed.

APPENDIX B
QUESTIONNAIRE FORWARDING LETTER



DEPARTMENT OF THE NAVY
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
WASHINGTON, D C 20363-5100

IN REPLY REFER TO

27 Jan 89

Mr. Ken Campbell
12240 Caminito Del Mar Sands
San Diego, CA 92130

Dear Mr. Campbell:

Effective management of technology is critical to our nation's defense, especially in view of the fact that we must offset Soviet numerical superiority with superior technology. The key to the success of this strategy is the effective transfer of technology from our research and development laboratories into fielded systems. There have been however, few quantitative studies undertaken to provide us with specific feedback to help us better understand this process or let us know how well we are achieving our objective.

The questionnaire attached as enclosure (1) will provide valuable information which will help us evaluate a critical link within the Navy acquisition process, the flow of innovative technology from DoD and industry laboratories to organizations such as yours which heavily influence the design of fleet systems. Our understanding of this process is critical if we are to realize maximum benefit from research and development products.

I would appreciate it if you would take the 15 minutes necessary to provide us this important information. If you have any questions or need further information, please contact Ken Campbell at AUTOVON 553-3014 or Commercial (619) 553-3014. Our target is to receive all responses by 28 February 1989. Thank you for your cooperation.

Sincerely,

E. B. TUNSTALL
Director of Navy Laboratories
By direction of the Commander

Encl:

- (1) Technology Innovation Environmental Assessment Questionnaire

APPENDIX C

FREQUENCY OF RESPONSE TO INDIVIDUAL
QUESTIONNAIRE QUESTIONS

Section A - Technology Source Identification

Never
Almost Never
Occasionally
Frequently
Almost Always
Always

1. Please indicate how often your code or office interacts with each of the following R&D communities when seeking innovative technology to meet existing or anticipated design requirements.

Navy Laboratories	5	7	42	76	91	125
Air Force Laboratories	122	89	64	37	12	2
Army Laboratories	140	87	61	26	9	3
Department of Energy National Laboratories	162	82	50	23	6	3
NASA Laboratories and Centers	159	86	48	22	4	5
Universities and University Affiliates	47	60	106	78	25	16
Private Industry	8	5	35	121	98	70
Other (please specify: _____)	8	2	11	11	6	9

2. How often does your code or office interact with each of the following specific Navy R&D organizations when seeking innovative technology to meet existing or anticipated design requirements?

David Taylor Research Center (DTRC)	81	69	78	41	28	37
Naval Air Development Center (NADC)	68	62	86	71	25	25
Naval Civil Engineering Center (NCEL)	210	75	33	10	4	0
Naval Coastal Systems Center (NCSC)	55	73	63	21	10	9
Naval Ocean Systems Center (NOSC)	35	49	91	75	51	40
Naval Personnel Research and Development Center (NPRDC)	199	69	47	14	0	0
Naval Research Laboratory (NRL)	22	48	97	93	44	35

Section A (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
Naval Surface Warfare Center (NSWC)	50	55	99	61	33	39
Naval Training Systems Center (NTSC)	144	100	58	16	10	4
Naval Underwater Systems Center (NUSC)	84	83	73	39	30	25
Naval Weapons Center (NWC)	85	69	82	49	28	22
Office of Naval Research (ONR)	72	78	96	53	29	7
Office of Naval Technology (ONT)	86	71	98	44	23	12

If you have indicated that your code or office never seeks innovative technology from any of the sources identified in questions 1 or 2, then you do not need to proceed further. For completeness of the survey records please return the questionnaire in the pre-addressed envelope provided. Thank you for your cooperation.

If you have indicated that you do seek innovative technology, please continue to the next question.

3. When seeking innovative technology, if you interact with any Navy R&D activities not listed in question 2, please list them here:

4. If you interact with private industry when seeking innovative technology, please identify key companies here:

Section B - Technology Area Identification

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
5. How often is your code or office involved in the following technology areas?						
Stealth (acoustic and electromagnetic signature reduction, including active and passive countermeasures)	91	35	78	65	26	41
Directed Energy (weapons schemes with intense focused energy)	192	53	56	16	4	15
Computing Power/Modeling (massive parallel processing, connection machines, high speed computational engines, etc)	99	57	62	69	22	30
Software Engineering (large-scale algorithmic systems, protocol communication among multi-processors, AI and expert system algorithms)	45	45	75	75	44	57
Fiberoptics and Photonics (fiber transmission lines, optical sources, sensors and components)	60	44	104	75	28	27
Nonconventional Energy (high-density energy storage, electromagnetic thrusters)	193	54	46	34	2	8
Superconductivity (materials, sensors, electric machinery)	172	67	60	20	10	10
Autonomous Vehicles (guidance and control, automatic targeting, intelligent subsystems, telecommunications)	123	56	64	41	19	36
Submarine Detection (active and passive, acoustic and non-acoustic)	127	30	58	35	17	70
Cooperative Engagement Technologies (inter-platform command control and communications, real-time data management and fusion, displays)	71	45	67	65	36	57
Application of Engineered Materials (biotechnology, coating materials, solid-fluid interaction, structural designs)	107	47	66	69	22	29

Section B (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
Information Management and Decision-making (application of statistics and logical decision elements, expert and computer-aided systems including neural networks)	50	50	92	71	32	42
Environmental Sciences (undersea and atmospheric propagation)	99	44	70	60	36	31
Insensitive Highly Energetic Materials (safe explosives and propellants)	190	45	33	35	13	21
Simulation Technology (large-scale interactive models, hardware-in-the-loop simulation and stimulation, training)	62	45	90	71	32	41
Space-based Systems (communications, surveillance, and data processing)	139	61	59	42	12	24
Multistatic Systems (all active sonars, acoustic and electromagnetic transmission)	109	48	58	50	26	44
Advanced Sensors (transducers and electromagnetic devices, navigation sensors)	81	48	64	54	40	52
Range and Test Technologies (measurement and processing of acoustic and electromagnetic signatures and signals)	77	55	71	63	38	35

Section C - Technology Transition Assessment

Not Important → Very Important

6. How important do you think each of the following factors are in the successful transition of new technology from R&D laboratories to 'technology user' organizations such as yours?

Clear documentation of the technology in a usable format and at an appropriate level of detail.	0	13	28	47	83	171
Ease of access to needed technical documentation or technical experts.	0	3	21	63	106	149
A supportive organizational climate which fosters the investigation and use of innovative new technology.	0	8	20	64	95	154
Consideration by the technology developer of the desired system performance requirements when undertaking new R&D projects.	2	9	17	69	109	135
The capacity and skills in the technology user organization to understand and apply new technology.	1	5	17	56	144	119
The credibility and reliability of the organization developing the new technology.	1	10	28	94	93	115
The presence of individuals who carry the news of useful new technologies to various potential users.	3	21	55	91	102	70
The willingness or internal motivation of individuals to search out and investigate the potential use of new technology.	1	8	29	73	111	118
Tangible and intangible rewards to those who pursue the adoption of innovative ideas and technology.	19	24	60	100	84	55
Structured or well defined communication channels for new technology information to enter an organization.	5	24	32	87	113	81

Section C (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
<hr/>						
7. Please indicate how often each of the following statements is true regarding <u>your immediate organization</u> .						
Engineers in my group possess the education, skills and traits necessary to seek out and implement new and innovative technology.	1	11	78	106	104	44
My colleagues discuss new and innovative technology developments.	0	21	77	109	87	51
Members in my group seek new and innovative solutions to system performance requirements.	0	13	86	107	84	54
Employees in my group that pursue new ideas, processes or products get promoted faster than their colleagues.	20	59	111	79	42	15
My immediate organization is supportive of the investigation and use of new and innovative technology.	4	18	57	83	95	87
My group has been successful in acquiring and implementing new and innovative technology.	0	20	115	100	66	41
8. Please indicate how often each of the following statements is true regarding the <u>companies in private industry</u> with which you interact. (If you do not interact with any companies in private industry skip this question and go on to the next one.)						
Industry generates clear documentation of new technology in a format and at a level of detail appropriate to my needs.	0	36	146	95	54	8
Industry allows easy access to needed technical documentation and information.	3	47	135	93	51	9
Companies in private industry consider my technology needs when undertaking new R&D projects.	0	24	106	106	83	16

Section C (con't)

	Never	Almost Never	Occasionally	Frequently	Almost Always	Always
The technical credibility and reliability of the companies I interact with is very high.	0	5	41	125	141	26
New technology information from industry comes through repeatable and well-defined channels of communication.	6	66	122	94	46	4
Private industry has been successful in providing innovative technology to meet my system performance requirements.	0	13	114	122	80	7
9. Please indicate how often each of the following statements is true regarding the Navy laboratories with which you interact. (If you do not interact with any Navy labs skip this question.)						
The Navy labs generate clear documentation of new technology in a format and at a level of detail appropriate to my needs.	3	39	134	103	49	4
Navy labs allow easy access to needed technical documentation and information.	1	26	83	100	101	20
Navy labs consider my technology needs when undertaking new R&D projects.	5	32	113	97	71	14
The technical credibility and reliability of the Navy labs I interact with is very high.	1	8	62	102	128	31
New technology information from Navy labs comes through repeatable and well-defined channels of communication.	9	54	107	106	47	9
The Navy labs have been successful in providing innovative technology to meet my system performance requirements.	3	33	144	91	52	7

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13 ABSTRACT (Maximum 200 words) This document discusses the various factors in the technology transfer model found to be significantly related to technology transfer success. Comparisons are made between the types of technology (e.g., process technology versus product technology), the success of for-profit versus not-for-profit organizations in supplying new and innovative technology.					
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